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LINEAR DRAWING AND LETTERING

J. C. L. FISH



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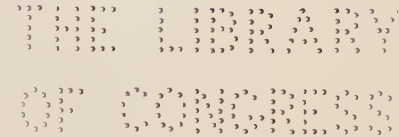
LINEAR DRAWING AND LETTERING

FOR BEGINNERS

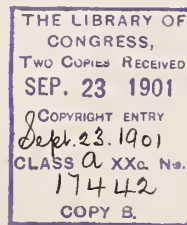
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PREFACE.

A faithful following of the directions given in this book will, it is hoped, furnish the student enough training in the use of drafting implements to enable him to construct accurate pencil drawings, make clean-cut ink lines, and do legible lettering.

The work embraced in Chapters II and III constitutes the course of fifty working hours in Linear Drawing and Lettering in Stanford University, as it has been given during the past eight years as preparation for the drafting in the courses in Descriptive Geometry, Elementary Machine Drawing, Surveying, and Graphic Statics.

I am indebted to Mr. C. B. Wing, Professor of Structural Engineering, and to Mr. G. H. Marx, Associate Professor of Mechanical Engineering, for many suggestions for this book.

J. C. L. FISH.

PALO ALTO, CALIFORNIA,
June 3, 1901.

TABLE OF CONTENTS.

CHAPTER I.—INSTRUMENTS AND MATERIALS.

§ 1. Equipment.

Instruments and materials required, 1.

§ 2. Instruments and Materials.

Drawing-board, 2-4.

T square, 5-7.

Triangle, 8-10.

Irregular or French curve, 11-13.

Drawing-paper and tracing-cloth, 14-16.

Pencil, 17-19.

Ruling-pen, 20-22.

Ink, 23-24.

Rubber pencil-eraser, 25.

Stale bread, 26.

Rubber ink-eraser, 27.

Steel ink-eraser, 28.

Pumice-powder, 29.

Scale, 30-32.

Divider, 33-35.

Compass, 36-38.

Compass lead, 39.

Compass pen, 40.

Bow instruments, 41-43.

Lettering-pen, 44-46.

Blotter, 47.

CHAPTER II.—A COURSE IN LINEAR DRAWING.

§ 3. To Lay Out and To Finish a Plate.

To fix the paper, 48.

Cutting line, 49.

Border line, 50.

To finish a plate, 51.

§ 4. Plate 1 : Medium Lines.

Full lines, 52.

Dash-lines, 53.

Dot-lines, 54.

Dash-dot-lines, 55.

§ 5. Plates 2 and 3.

Plate 2: Heavy lines, 56.

Plate 3: Fine lines, 57.

§ 6. Plate 3a : Circles.

Pencil circles, 58.

Pen circles, 59.

§ 7. Plate 4 : Accurate Construction.

To construct the square, 60.

To bisect an angle, 61.

To inscribe a circle, 61.

To divide a line into equal parts, 62.

To ink Plate 4, 63.

§ 8. Plate 5 : Irregular Curve.

To use the French curve, 64.

To construct Plate 5, 65.

CHAPTER III.—A COURSE IN LETTERING.

§ 9. Required Work in Lettering.

Materials for lettering, 66.	Plates 6 and 7 : Ordinary lettering, 68.
Preliminary practice, 67.	Plates 8-17 : Titles, 69.
	Final work on plates, 70.

§ 10. Vertical and Inclined Lettering. Introductory Remarks.

Directions of letter-stems and axes, 71.	Difference between Vertical and Inclined lettering, 75.
Horizontal guides, I-guides, 72.	Letter widths, 76.
Individual pen-strokes, 73.	Letter- and word-spacing, 77.
O as a model for curve forms, 74.	

§ 11. Vertical and Inclined Lettering. Details of Letters.

Details of lower-case o, 78.	Details of C D G J S U, 85.
Details of a b d g p q, 79.	Details of B P R, 86.
Details of c e s, 80.	Details of E F H I L T, 87.
Details of h m n r u, 81.	Details of A K M N V W X Y Z, 88.
Details of f i j l t, 82.	Details of numerals and fractions, 89.
Details of k v w x y z, 83.	
Details of capitals O Q, 84.	

§ 12. Titles.

Arrangement and proportions of the parts of a title, 90.	Common faults in titles made by beginners, 91.
	To construct a title, 92.

CHAPTER IV.—INTRODUCTION TO DRAFTING.

§ 13. The Paper and the Scale.

Drafting, 93.	To cut the paper, 96.
Choice of paper, 94.	To stretch the paper, 97.
To draw to scale, 95.	

§ 14. Linear Drawing Applied to Drafting.

To pencil a drawing, 98.	Margins, border line, 101.
To ink a drawing, 99.	Conventions, 102.
To make a tracing, 100.	

§ 15. Lettering Applied to Drafting.

Choice of styles, 103.	To make the letters and figures, 105.
Size and position of letters and figures, 104.	The title of a drawing, 106.
	Lettering on tracing-cloth, 107.

LINEAR DRAWING AND LETTERING.

CHAPTER I.

INSTRUMENTS AND MATERIALS.

§ 1. *Equipment.*

1. Instruments and Materials Required for the work in this course in Linear Drawing and Lettering :

- | | |
|---|--|
| 1 HHHHHH pencil. | 1 45° triangle, 10", wood, rubber, or celluloid. |
| 1 HHHH pencil. | 1 60° triangle, 10", wood, rubber, or celluloid. |
| 1 emery pad for sharpening pencils. | 1 triangular boxwood scale, Architect's. |
| 1 pencil-eraser, rubber. | 1 piece chamois for cleaning pen. |
| 1 ink-eraser, rubber. | 1 irregular, or French, curve, K. & E. 19, T. |
| 1 doz. thumb-tacks or drawing-pins. | A. & Sons 16, or similar, celluloid. |
| 1 drawing-board, not less than 17" x 24". | 1 penholder, swell body. |
| 1 T square of same length as the board. | 6 Gillott's pens 303. |
| 1 bottle water-proof drawing-ink, black. | 6 Gillott's pens 404. |
| 1 sheet Whatman's N. paper, Double Elephant size. | 6 Leonardt's 506 F, ball-pointed pens. |

LINEAR DRAWING AND LETTERING.

1 case of instruments (every instrument numbered below bears the maker's trade-mark as stated in the foot-note), as follows :

1 $5\frac{1}{2}$ " ruling-pen, T. A.* 1615, Kern† 405, K. & E.‡ 523 $\frac{1}{2}$.

1 $3\frac{1}{2}$ " bow divider, T. A. 1580, Kern 462, K. & E. 485.

1 $5\frac{1}{2}$ " compass, T. A. 1434, Kern 651, K. & E. 610H.

1 metal case of HHHHHH leads.

1 screw-driver and key-wrench (for adjusting instruments).

The instruments named above and the pocket-case named below are necessary for the course in Linear Drawing. The instruments named below are desirable for the

Linear Drawing course and necessary for the work in advanced engineering courses.

1 5" hair-spring divider, T. A. 1423, Kern 642, K. & E. 608.

1 $3\frac{1}{2}$ " bow pen, T. A. 1585, Kern 463, K. & E. 486.

1 $3\frac{1}{2}$ " bow pencil, T. A. 1582, Kern 464, K. & E. 487.

1 leather folding pocket-case, *made to hold* the following instruments :

2 $5\frac{1}{2}$ " ruling-pens,

1 $3\frac{1}{2}$ " bow divider, 1 $3\frac{1}{2}$ " bow pen, 1 $3\frac{1}{2}$ "

bow pencil,

1 5" hair-spring divider,

1 $5\frac{1}{2}$ " hair-spring compass (fixed needle-leg,
pen, pencil, lengthening bar),

1 screw-driver and key-wrench,

1 metal case of HHHHHH leads.

*T. A. stands for T. Alteneder & Sons, 945 Ridge avenue, Philadelphia. Every instrument stamped "T. A.," or "T. A. & Sons," or "T. Alteneder & Sons."

† Kern stands for Kern & Co., Aarau, Swiss. Every first-class instrument stamped "Kern & Co."

‡ K. & E. stands for Keuffel & Esser Co., 127 Fulton street, New York. Every first-class instrument stamped "K. & E. Co., N. Y., Paragon," or "Keuffel & Esser Co."

It is well to purchase at the start, if possible, all the instruments named above as necessary or desirable, together with the case, which is made to hold all these and an additional pen. If the student cannot afford to do this, he buys the necessary instruments for the Linear Drawing course, and the case, and fills the vacant spaces in his case as additional instruments become necessary from time to time in his engineering courses. Two spaces in the case are made for pens, for a second pen will be needed before the first one is discarded.

For prices, see the catalogues of the firms named above.

§ 2. *Care and Use of Instruments and Materials.**

2. Drawing-Board.—Drawing-boards are made in different sizes, corresponding to regular sizes of drawing-papers. The simplest board is made of soft wood in one piece. This is improved by lining each sawed end with a narrow strip of hard wood to prevent the warping of the board, and to give a smoother surface for the head of the T square to slide on. The best boards are made up of narrow strips of soft wood held together by cleats so attached to the back of the board that shrinkage can be taken up at any time; and each end is lined with a hard-wood strip. It is necessary that the left end of the board be a straight-edge, and desirable that the near edge of the board be straight, and perpendicular to the left edge.

* For a fuller knowledge of the varieties of instruments and materials, the reader is referred to the catalogue of a mathematical instrument maker.

3. Care of Drawing-Board.—The edges of the board should be kept free from indentation, and the upper surface smooth except for the holes made by thumb-tacks. The board, when not in use, should lie on a flat surface or stand nearly vertical on one end to prevent warping.

4. Use of Drawing-Board.—A rectangular piece of drawing-paper, cut to required size, is placed on the board so that the edges of the paper are parallel to those of the board (as determined by the T square if the paper is small compared with the board), and each corner of the sheet is tacked down with a thumb-tack. It may be necessary to use additional thumb-tacks on the paper edges to make it lie smooth.

5. T Square.—See Fig. 1. The simple T square has its blade rigidly fastened to its head. Others have an adjustable connection which permits setting the blade at any angle with the head. The cheaper T squares are made of wood, the head of one piece and the blade of another. The better grades have the inner edge of the head (which slides in contact with the board) and both edges of the blade, lined with narrow strips of hard wood or celluloid. The best are made of metal throughout.

6. Care of T Square.—The T square ought to lie flat on the drawing-board or be hung, head down, against the wall, when not in use. Keep the edges of the blade free from nicks. Do not use the T square as a hammer, nor the T blade as a guide for a knife.

The blade of the T square is said to be less apt to soil the paper if it is covered on its lower side, to within a quarter-inch of each edge, with thin blotting-paper.

7. Use of T Square.—The upper or far edge of the T blade may be used as a guide for pen or pencil when drawing a straight line in any direction, but serves especially as a guide when drawing horizontal lines, *i. e.*, lines perpendicular to the left edge of the drawing-board,

and as a guide for one edge of the triangle while another edge is serving as a guide for the pen or pencil. Press the T head firmly against the left edge of the board before beginning to draw, and be sure that it remains there while drawing each horizontal or vertical line.

The inner edge of the T head and left edge of drawing-board being straight, all positions of the T blade are parallel when the T head is pressed firmly against, and moved along, the left edge of the board.

The T blade cannot be depended on to lie flat on the drawing throughout its length nor to keep its place without pressure from the hand. While drawing a line from the head to mid-point of blade, bear the left hand on the quarter-point nearest the head; and when drawing a line along the outer half of the blade, press the blade down, with the left hand, at the quarter-point nearest the end of the blade.

8. Triangle.—Triangles are of many forms. Fig. 21 shows one form of triangle whose angles are 90° , 60° , and 30° (called a 30-60 triangle), and another whose angles are 90° , 45° , and 45° (called a 45° triangle). These are the forms most commonly used. Triangles are made in many sizes, and for those which have one 90° angle the size is given as the length of the longer perpendicular edge. Written in the order of cost, triangles are made of the following materials: wood, wood with lined edges, hard rubber, celluloid, German silver, aluminum, and steel.

9. Care of Triangle.—The triangles should be kept well cleaned to prevent their soiling the drawing-paper. To save the paper, the triangles should be moved over it as lightly as possible. If thin blotting-paper be pasted on the triangle to within a quarter-inch of the inner and outer edges it will be less apt to slip and soil the paper. This may not be desirable for the celluloid triangles, as it may detract from their value due to transparency. Triangles

should, when idle for any length of time, lie on a flat surface to prevent warping. Do not use a triangle as a guide for a knife when cutting paper or trimming plates.

10. Use of Triangle.—Any edge of a triangle will serve as a guide (a straight-edge) to pen or pencil when drawing a straight line. The special use of a triangle is in drawing sets of parallel lines (Fig. 21). The altitude serves as a guide for vertical lines when the base is in contact with the upper edge of the T blade and the T head is pressed firmly against the left edge of the board. Sets of lines, making 45° , 30° , and 60° angles with the horizontal, can be drawn by using the triangles in connection with the T square, the head of which is pressed firmly against the left edge of the board.

11. Irregular, or French, Curve.—French curves are made of wood, hard rubber, and of celluloid. One form is shown in Fig. 19, which is one-third of the actual size.

12. Care of French Curve.—While idle, the curve should lie on a flat surface. Keep the edges of the curve free from indentations. Clean the curve often enough to prevent accumulations of oil and dirt, which rub off on the paper. Pasting strips of thin blotting-paper on the under side of the hard rubber will prevent its soiling the paper; but this device lessens the value of the celluloid as a transparent curve.

13. Use of French Curve.—This is explained in 64.

14. Drawing-Paper.—Drawing-papers are divided into three classes: I. "Drawing-paper," II. Detail-paper, and III. Tracing-paper and tracing-cloth.

I. The term *drawing-paper* is usually reserved for the better grades of paper which are intended for drawings that are to be finished directly in pencil or ink. It is sold in sheets of different sizes, and in continuous sheets, or rolls, of different widths. It may be mounted (*i. e.*, backed by muslin) or unmounted. It is made in great variety of weight, surface, and quality, to

suit all kinds of work. The surface may be "H. P." (hot-pressed, which is smooth), "N." (not hot-pressed, which has a fine-grained surface), "R." (which is rough-grained), or "egg-shell" (which has a surface resembling a rough-surfaced egg-shell).

II. *Detail-paper* is the name given to the cheaper papers, suitable for rough and medium-fine pencil drawings which are to be finished by tracing, if at all. This, like the above, can be obtained in sheets and rolls, and of many weights and surfaces.

III. *Tracing-paper* is transparent, and sometimes used for tracing, in pencil or in ink, a design first drawn on a piece of detail-paper. *Tracing-cloth* is a transparent cloth (called also *velum*), and is the material generally used for tracings, because of its toughness. It may be obtained in sheets of different sizes and in rolls of different widths. There are several grades.

15. Care of Drawing-Paper.—Sheets should lie flat when put away, or be rolled loosely. The rolls should be kept free from pressure, which breaks the surface. The paper should at all times be kept from dust and moisture. Spread and tacked on the drawing-board, the paper should be protected from dust, and the instruments and hands should come in contact with the paper as little and as lightly as possible. There is always more or less perspiration on the hands, and the T square and triangles are seldom so clean that the paper may not be soiled by their rubbing.

When making several drawings on one sheet, it is well to cover it with a protecting paper from which a piece is cut to expose that drawing which is being made at the time. If intervals of hours or days are to elapse between periods of work, the paper should be protected, as above, or removed from the board and put away.

The hard erasing which is required to remove the dirt from a soiled drawing injures the surface of the paper and the ink-lines which have been drawn. A neat drawing is produced by

keeping the paper so clean that there is no need of rubbing and scrubbing at the end. If convenient, the hands should be washed frequently during a drawing period, especially in warm weather.

16. Use of Drawing-Paper.—The upper side of the paper is generally that which shows the water-mark or trade-mark right side up. The rough side of egg-shell paper is for drawing. Many of the smoother and thinner papers are about the same on both sides. Tracing-cloth may be used either side up. Some draftsmen condemn the use of the rough side because ink-lines made on this side are ragged, and erasures cannot well be made. Others use the rough side, because drawings so made lie flat instead of rolling up, and pencil work can be done on this side. If the smooth side is to be used for ink-lines, it should first be dulled by rubbing with pumice powder. The powder must be thoroughly removed before inking the lines, for it clogs the pen.

When about to touch ruling- or common pen to paper at any place, press the paper flat against the board and keep it there till the line is done and the pen has been lifted from the paper. Otherwise there will usually be made a blot or a tail at each end of the line.

17. Pencil.—Faber's HHHHHH or Koh-i-noor HHHHHH pencil should be used for all drawing in this course, except that for coarse work and lettering the HHHH grade should be used. No accurate drawing can be done without smooth lead of proper hardness.

18. Care of Pencil.—For the *cone-point* (see Fig. 14) cut away the wood at the end opposite the printing, to expose at least one-half inch of lead. Rub the exposed lead flatwise over fine-grained emery-paper while twirling the pencil between the thumb and fingers, till the sharp-tipped cone-point is formed. Next, rub the lead in a similar manner on rough-surfaced paper until the tip of the cone-point, when viewed endwise, is invisible. This point is easily broken, and it must rest on the paper with very little pressure while drawing a line. The cone-

point is used where the greatest accuracy is required, as in Graphics, but is not as serviceable as the chisel-point for drawing lines which must be distinct enough to show through tracing-cloth. The dull cone-point is used for printing figures and descriptions on a drawing, and for free-hand curves.

For the *chisel-point* (Fig. 13), expose a half-inch of lead. Rub two opposite sides of the lead flatwise on the emery-paper, till a sharp chisel is formed. Next, repeat the rubbing on drawing-paper until the edge of the chisel is invisible. The chisel-point, when applied with pressure, rules a line which is fine enough for working-drawings, and yet distinct enough to show clearly through tracing-cloth. The cone-point, of equal sharpness and applied with the same pressure, either breaks, or wears away too rapidly. The cone-point admits of greater precision, and, for drawings which are to be redrawn directly in ink, rules sufficiently distinct lines.

After drawing each long line, or a few short ones, examine the pencil-point, and if it reflects light when viewed endwise, resharpen by rubbing on a piece of drawing-paper. The emery-paper need be used only when resharpening on paper takes too much time. It is well to have in use two pencils, one with cone- and the other with chisel-point. Neither chew the pencil nor wet the lead in the mouth.

19. Use of Pencil.—A hair-line is drawn with the sharp cone-point, with slight pressure. It is distinctly visible by diffused light, but may be invisible when the paper reflects light to the eye from a window. It is easily erased, leaving no trace. The intersection of two hair-lines determines a point with precision. (A determined point should be marked faintly with needle-point or pencil tip, and enclosed, for ready finding, in a small circle drawn free-hand with pencil.)

The most accurate drawings are first constructed with hair-lines. Afterward, some of the

lines may be made heavier ; but when retracing a hair-line with the pencil, make a break in the heavy line at each accurately determined point, that it may not be obliterated.

In accurate work, hold the pencil as carefully as the ruling-pen. Hold the pencil perpendicular to the paper, with the exception of a slight slant in the direction of motion. When drawing any line, free-hand or otherwise, with the pencil, do not bear down enough to make a groove in the paper, unless absolutely certain that no part of the line will require erasure.

The chisel-pointed pencil should be so held that the chisel edge has the direction of the line which it is ruling.

If the guide is pressed firmly on the paper at every point as it is reached, the pencil may be given an outward slant to bring the tip of the lead against the lower edge of the guide. But if the pencil is thus held, and the guide is in contact with the paper only for portions of its length, the pencil point will trace a crooked line.

Slant the pencil neither outward nor inward, reaching for a point through which the line is to be drawn ; but bring the guide to such a position that the pencil tip will precisely touch the point when the pencil is held in correct position, against the guide.

20. Ruling-Pen.—(Fig. 20.) Ruling-pens are made in three or more sizes. The simplest have fixed blades. The outer blade, in one form, is so made that its upper end acts as a spring to throw the blades a little apart when released by the set-screw. The blades of the hinge-blade pen may, on releasing the set-screw, be thrown open through an angle of 90° or more. Other pens are so made that the blades can be opened wide and again closed, without disturbing the set-screw. Some pen handles are made to unscrew, and carry a needle-point, which may be used for marking points with precision, and for transferring a drawing from one sheet to another, by pricking through the original. Pens are also made for special work, as the curve-pen for drawing contours, the railroad-pen, and the border-pen.

21. Care of Ruling-Pen.—(Fig. 20.) The nibs of the ruling-pen should be of the same width, so that, when brought together, one nowhere overlaps the other. They should be so sharp that, when viewed endwise, they reflect no light, and yet not sharp enough to cut the paper. It is easy to break a piece from a sharp nib by careless handling. A roughness of the points may be invisible to the naked eye and yet make the pen scratch the paper (Fig. 25). When the pen scratches, or is dull (as shown by reflected light at the points), it should be sharpened by rubbing the outside surfaces of the nibs on a fine Arkansas oilstone, while holding the pen at an angle of about 20° with the stone. To make the points of equal length, draw the pen lightly across the stone, as in drawing a line on paper; at the same time rock the pen, in the plane of motion, to round the nibs. Frequently examine the points through a magnifying-glass during the grinding. The frequency of required sharpening depends on the hardness of the steel in the points, and on the use given the pen. Detail-paper wears a pen rapidly, and it is not economy to use such paper for drawings which are to be inked. In some offices a pen which is in constant use is sharpened daily. Usually a beginner should practice grinding an old pen before trying to sharpen a new one. An instrument-maker will properly sharpen a pen for about twenty-five cents.

Do not let the ink dry in the pen. Before laying it aside for a few minutes, shake out the ink and wipe the nibs, inside and outside, with cloth or chamois. At the end of a period of work, wipe or wash off all traces of ink, and put the pen away with its nibs bright and thoroughly dry. Fig. 25 is an enlarged sketch of the inner face of the nib of a ruling-pen which has not been kept scrupulously clean.

22. Use of Ruling-Pen.—The opening between the nibs of the pen is made, by means of the set-screw (Fig. 20), equal to the width, or thickness, of line to be drawn. When setting

the pen for fine lines be careful that the nibs are not made to touch each other. Usually the required opening between the nibs is determined by trial after the pen is filled with ink. Once set to give the desired width of line, the set-screw should not be touched until it is required to draw lines of another width, or to clean the pen. A piece of paper, cloth, or chamois is run between the nibs without disturbing the setting, to remove ink which, thickened by evaporation, partially closes the outlet.

To fill the pen with ink: Take the pen to the bottle. Hold the pen, nibs up, between the thumb and first finger, and the bottle (which rests on the table) between the little finger and palm, of the left hand. Remove the stopper from the bottle with the right hand, and, by means of the quill inserted in the lower side of the stopper for the purpose, transfer the ink, drop by drop, from bottle to pen. Move the quill point upward between the nibs, if necessary, to insure the complete transfer of the ink drop. The pen is too full only when the ink spills out on a slight, sudden motion of the pen. A little experience will determine the proper amount of ink to put in the pen. Do not wait till the pen is empty to refill it, for the width of the line ruled changes slightly with the supply of ink. Always keep the exterior of the nibs absolutely free from ink; otherwise ink will come into contact with, and run under, the guide, making a blot. Furthermore, ink, wet or dry, on the exterior of the nibs, interferes with the ruling of clean-cut lines.

To rule a line: Hold the pen perpendicular to the paper, with the axis of the set-screw perpendicular to the direction of the line to be drawn, and with the screw head on the far side of the pen. Move the pen from left to right. The weight of the hand is carried by the third and fourth fingers, which rest upon, and move along, the guide. Do not press the pen against the guide, for this tends to close the pen opening. In beginning to draw a line, after the pen has been placed at the starting-point, put the head directly in front of the pen, to see that the

handle has no slope to right or left. Then, place the head in such a position that the eyes are about ten inches above the guiding edge, and about ten inches to the left of the pen. With the head in this position, the inside faces of the blades are equally visible when the set-screw axis is perpendicular to the direction of the line to be drawn. In moving the pen to the right to rule the line, the hand should swing neither about the elbow nor shoulder, as a pivot. Simply move the body to the right, carrying the hand and arm with it. Beginners usually make the mistake of placing the head directly above the pen nibs, to see which then requires the pen handle to be thrown to the right. See Figs. 40, 41.

Reach neither in nor out, with the pen, to make the nibs pass through a given point; but bring the guide to such a position that the nibs will pass precisely through the point while the pen is held correctly, in contact with the guide. Study Figs. 6, 7, 8, 9, 10, and 11 in connection with this article.

23. Ink.—Formerly all drawing-ink was prepared for use, day by day, by rubbing stick India-ink on the bottom of a dish wet with a small quantity of water. Now, ready-made liquid drawing-inks are most commonly used. These are made water-proof and non-water-proof, in black and in colors. Water-proof ink should be used for most drawings. Non-water-proof may flow a little more freely than the water-proof ink, but a drawing made with the former is easily smeared by handling. Do not waste time and make poor lines in attempting to economize by using the dregs of an old bottle.

24. Care and Use of Ink.—Keep the bottle well corked at all times when not actually taking out ink, which rapidly deteriorates by evaporation. Keep the bottle off the drawing. The ink may be thinned by adding some drops of water, alcohol, or ammonia, when it has become too thick, but this mixture is not as good as new ink. Remove ink at once from all

surfaces to which it has come by accident. Leave ink to dry neither on the ruling- nor lettering-pen, as it corrodes, and thus injures, the nibs. Flies take up ink, and should be kept from drawings, especially those made on tracing cloth, while ink-lines are wet.

To supply the ruling-pen with ink, follow directions under 22. The lettering-pen is dipped in the ink as in ordinary writing, but the stopper must be replaced in the bottle after each dip.

25. Rubber Pencil-Eraser.—The best eraser is that which wears away so rapidly as always to present a fresh surface. Erasers harden with age, and finally injure the paper without properly removing pencil lines. Before applying it to a drawing, the end of the eraser is cleaned by rubbing it on a piece of fresh paper. Erase gently, especially over ink lines. Too energetic erasing dulls ink lines and roughens the paper surface. The rubbing should be done in the direction of ink lines rather than across them. If, in spite of care, a drawing becomes grimy, clean it with stale bread (26).

26. Stale Bread.—Stale bread does not erase pencil marks well, but removes grime from a drawing, while leaving the ink lines brighter, and the paper surface fresher, than when rubber is used. The soft interior of the loaf is broken out in handfuls and rubbed over the drawing, fresh pieces being added as that in use becomes soiled or crumbles from under the hand, which is held nearly flat.

27. Rubber Ink-Eraser.—This should be cleaned at the working end, before it is applied to the drawing, by rubbing on a piece of fresh drawing-paper. The ink to be removed should have been drying for an hour, preferably a day. As the ink-eraser cuts the paper rapidly, care should be taken to rub as little as possible beyond the ink surface to be removed. For erasing lines it is a good plan to make a stencil of heavy paper or very thin sheet-metal, through a slit in which the erasing is done. The rubber ink-eraser is generally used after the

greater part of the ink has been removed with the steel ink-eraser or sharp blade of a knife. The erased surface should be put in condition to take ink, by means of pumice powder (29).

28. Steel Ink-Eraser.—This is used to remove ink which has been placed on a drawing by accident or mistake. A sharp pocket-knife serves the same end. It should be held so that the blade stands nearly perpendicular to the paper, and with the edge almost parallel to the ink line to be erased. It should be held firmly, so that, if possible, in moving backward and forward along the line over a short space, it will remove the crust of ink and leave the paper surface beneath and at the sides of the line undisturbed. The ink should have dried at least an hour before using the eraser. It ruins the paper surface to try to erase while the paper is yet moist from the ink. A dull eraser injures the paper without satisfactorily removing the ink. Pumice powder (29) is better than steel for erasing ink from tracing-cloth.

29. Pumice Powder.—This is used to remove ink from tracing-cloth, to prepare the glossy side of tracing-cloth for drawing, and to resurface drawing-paper where it has been roughened by the ink-eraser. To use as an ink-eraser, rub the powder over the ink to be removed with the finger or soft rubber. Supply fresh powder as that in use becomes soiled. The powder must be thoroughly removed from the cloth before applying the pen. Apply the powder, by means of a soft rubber or piece of paper, to resurface roughened drawing-paper.

30. Scale.—The ordinary two-foot rule is a scale divided naturally, *i. e.*, each unit (one inch) is divided into halves, quarters, eighths, sixteenths, thirty-seconds, or sixty-fourths. The *engineer's* scale is divided decimally. Each unit (which may be one inch, or one-half, one-third, one-fourth, one-fifth, one-sixth, one-eighth, or one-tenth of an inch) is divided into ten equal parts. The *architect's* scale is divided duodecimally. Each unit (which may be one inch, three inches, three-thirty-seconds, one-eighth, three-sixteenths, one-fourth, three-eighths, one-half, three-

fourths, or three-halves of an inch) is divided into twelve equal parts. The form of scale (rule) most commonly used by students, and known as the *triangular* scale, has a triangular cross-section, and is made of boxwood, boxwood faced with celluloid, or metal. It is used in preference to a *flat* scale only because, by its form, it presents a greater number of edges for graduation. The best scales are engine-divided; the cheaper scales are stamped.

31. Care of Scale.—Use a scale as a guide for neither pen nor pencil. Such use of the scale injures its edges, which, with the graduation faces, should be kept free from marks and indentations.

32. Use of Scale.—Only the natural scale need be used in the work outlined in this course. To lay off a given distance from a given point on a given line: Place the triangular scale on the paper so that the edge which is divided to sixteenths of an inch lies parallel, and as near as possible, to the given line, and the zero mark of this edge is precisely at the given point. Then make with the needle-point, or cone-pointed pencil, a minute mark on the given line precisely under that mark of the scale which lies at the given distance from the zero mark. To be sure that a scale mark is precisely at a given point on the paper, or *vice versa*, the head must be placed above the scale, so that you look directly along the scale mark. The utmost precision is required in laying off and measuring distances when aiming at extreme accuracy, as when drawing Plate 4. The divider should not be used to transfer distances from scale to paper nor from paper to scale, for this practice involves loss of time and accuracy (35).

33. Divider.—Dividers are made in different forms and sizes. One form is shown in Fig. 23. The set-screw, near the middle of one leg, controls the hair-spring, the action of which is shown in Fig. 22 and explained in 36.

34. Care of Divider.—Draw no circles with the divider. The divider legs should open

with only sufficient friction to hold the legs, with careful handling, at any desired opening. The friction at the head joint is regulated by means of the screw-driver provided for that purpose. The adjustment should be carefully made, to avoid injuring the screw threads. Wipe the steel surfaces of the divider dry with soft cloth or chamois when replacing them in the case. Keep the divider, when not in use, in the case, to prevent accident to the points.

35. Use of Divider.—The divider is used to transfer distances from place to place on a drawing, and from one drawing to another. Its chief use is in laying off a given distance a number of times, and in dividing a given line into a given number of equal parts (62). Transferring distance by means of the divider from scale to paper and paper to scale is now poor practice, though formerly the awkward form of the scale used made it necessary. Do not push the divider points into the paper farther than is necessary to make the smallest visible hole, which may be readily found again if it is enclosed with a pencil mark. Work requiring a small divider opening is best done with the bow divider (41–43).

36. Compass.—Compasses are made in three or more sizes and of many forms, one of which is shown in Fig. 22. The compass set includes all the parts shown in this figure, which should be studied in connection with the instruments themselves. On turning the set-screw which controls the hair-spring, the needle leg moves toward the opposite compass leg. By this means a minute change in the opening (or spread) of the compass is easily made. The pen leg, pencil leg, and the lengthening-bar may be inserted in, and removed from, the compass leg at will. The needle leg, in the style of compass here shown, is fixed to its compass leg. The point of the needle, which is clamped in the foot of the needle leg, serves as the pivot about which the compass rotates when drawing a circle. One end of the needle is a cone-point and the other a shoulder-point. Use the shoulder-point. The lengthening-bar is inserted between

the compass leg and the pencil or pen leg only when, without it, the distance between needle-point and marking-point would not be sufficient to draw a circle of given radius.

37. Care of Compass.—The friction of the head joint is regulated in the manner described in 34. The steel surfaces of the compass and parts should be wiped dry with soft cloth or chamois to prevent rusting, when put away in the case. The pen leg must be cared for with the thoroughness prescribed for the ruling-pen (21). All the screws used should be turned with a delicate touch, for they are small and easily injured by too tight setting.

38. Use of Compass.—To draw a circle, the compass handle is taken between the right thumb and first finger, and the needle-point is guided to the circle center by the left hand. By trial, make the needle leg and pencil leg perpendicular to the paper while making the distance between their points equal to the radius of the circle to be drawn. A minute change in the distance between the points is best made by turning the set-screw of the hair-spring with the left thumb and first finger (Fig. 22) while the needle-point is at the circle center. To prevent the needle-point's making a hole at the circle center, keep the needle leg as nearly as possible perpendicular to the paper and let the needle rest with only enough pressure on the paper to prevent its slipping. For accuracy, the needle mark at the center of a circle or set of concentric circles must remain so minute as to require enclosing in a small free-hand circle for ready finding. Small circles are best drawn with bow pen and bow pencil (41-43).

39. Compass-Lead.—The lead in the pencil leg should be HHHHHH, and if this cannot otherwise be had, cut a piece from the HHHHHH pencil. Sharpen the lead to a chisel-point (18), making the edge of the chisel precisely tangent to the circle which it draws. In accurate figure construction the circle lines must be as fine as it is possible to make them—as fine as are the straight pencil lines for the same class of work (19).

40. Compass Pen.—If the blades of the pen leg are of equal length, the pen leg should be perpendicular to the paper when drawing a circumference, for in this position the two nibs will come into full contact with the paper, and the line drawn will be smooth on both edges. If the two blades of the pen are of unequal length, the pen must be given a slant, which is found by trial, just sufficient to make the nibs touch the paper with equal pressure. Study Fig. 17.

41. Bow Instruments.—Fig. 24 shows the center-wheel style of bow divider. In another form the adjusting wheel is placed on the outside of one of the legs. The bow pen and bow pencil are like the bow divider from the handle down to and including the adjusting wheel. One leg of the bow pen terminates in a needle; the other carries a pen, which should be cared for in the manner described in 21. The bow pencil carries in one leg a needle, and in the other a piece of lead. This lead should be, for accurate work, exactly like that described in 39.

42. Care of Bow Instruments.—The instruments should be wiped dry before they are put away after each work period. They should be in the case when not in use. They must be handled with care, that their points may remain in good condition. To change the opening (or spread) of the side-wheel bow instrument, with the left thumb and first finger gently press the points inward to decrease the friction on the wheel; then turn the wheel. The final adjustment must still be made with the points released.

43. Use of Bow Instruments.—The bow divider takes the place of the ordinary divider (33–35) when a small divider opening is required. The two other bow instruments are used in preference to the ordinary compass (36–40) for small circles.

44. Lettering-Pen.—Any of the many styles of steel pens used for writing may be used for lettering. That pen which is best adapted to a given person for a given piece of work, can

be determined only by trial. The coarseness of the pen point should correspond to the thickness of the stroke to be made. In the order of coarseness, Gillott's 303 and 404, and Leonardt's 506F ball-pointed pens are satisfactory.

45. Care of Lettering-Pen.—It is well to break in a new pen before using it on a drawing. First remove the protective oil coating by alternately dipping in the ink and wiping the pen dry with a soft cloth or chamois. The lettering-pen should be used only with drawing-inks, not with writing-inks and fluids. The pen should be wiped clean with soft cloth or chamois each time the ink on it is used up, and at the end of each period of pen work. The pen should not be dipped deeper than just above the eye, in the ink. Wipe from the holder the ink which gets on it at the neck of the bottle.

46. Use of Lettering-Pen.—Keep the bottle off the drawing-paper and take the pen to the bottle when about to dip. After dipping, jar the pen to shake a surplus drop or two back into the bottle, and at once recork the bottle. Carry the pen from the bottle to the paper, in a horizontal position, ink side up, to prevent possible blots.

The pen must be pressed on the paper at the starting-point of a stroke, with the weight which is to be applied throughout the stroke. The beginner must consciously divide the work of making each stroke into the following efforts:

- (1) Place the pen point at the point for beginning the stroke.
- (2) Press the pen on the paper to make the width of stroke desired (the beginner should use very little pressure).
- (3) Keeping this pressure constant, move the pen to form the stroke.
- (4) Stop the pen at the stroke end.
- (5) Lift the pen vertically from the paper.

In this way only can clean-cut strokes be made. The skilled letterer goes through the same distinct efforts, but almost unconsciously.

The penholder should be held to make with the paper as small an angle as is easily possible. In this position the pen nibs are less apt to pick up the fibres of the paper than when held more nearly perpendicular to the paper.

47. Blotter.—A blotter is never used to blot a drawing as one blots a piece of writing. If ink is spilled on a drawing, the blotter is so placed that it will draw up the ink without coming in contact with the paper surface. When the flow of ink has been too rapid from a lettering- or ruling-pen and the ink is piled high, so that there is danger of its breaking over the proper limits of the line, tear a piece from a blotter and bring the tip of this carefully down to the top of the ink globule to absorb the surplus without spreading the remainder over the paper.

Under all ordinary conditions the ink lines are given time to dry. Beginners are apt to get impatient and hasten the drying by blotting, as in writing, and in this way ruin the lines so treated.

CHAPTER II.

A COURSE IN LINEAR DRAWING.

§ 3. *To Lay Out and To Finish a Plate.*

48. To Fix the Paper.—Fold a Double Elephant sheet of drawing-paper three times, in this way: (1) fold the long way of the original sheet; (2) fold the long way of the doubled sheet; (3) fold the long way of the quadrupled sheet. Cut the paper along the folded edges, making 8 sheets, each a little larger than 9" x 12" (9 inches by 12 inches).

Fig. 1. By means of thumb-tacks (one in each corner of the paper), fix one of these 9" x 12" sheets to the drawing-board, in such a position that the blade of the T square will be parallel to the long edges of the paper when the T head slides along in contact with the left edge of the board. Additional tacks along the edges of the sheet may be required to hold the paper flat. For another method of fastening the paper to the board see 97.

49. Cutting Line.—On the sheet of paper thus fixed draw a rectangle, thus (Fig. 2): Press the head of the T against the left edge of the board, while the blade lies flat on the paper.

Slide the head of the T along in full contact with the left edge of the board, till the upper edge of the blade is $\frac{1}{2}$ " above the lower edge of the sheet.

Along the upper edge of the blade while in this position, draw a pencil line on the paper (17-19).

With the pencil make a fine dot on this line about $\frac{3}{4}$ " from the left edge of the sheet. Enclose this dot in a small free-hand pencil circle, that it may readily be found (19), and mark it *a*, as in Fig. 2.

Lay off on this line to the right of *a* the distance $ac = 12"$ (32). Place a dot at *c*, the right extremity of this distance.

Slide the T head along in full contact with the left edge of the board till the upper edge of the blade is below the penciled line *ac*.

Place a triangle with one of its perpendicular edges against the upper edge of the blade, as shown in Fig. 1.

Slide the triangle along in full contact with the blade, till the edge perpendicular to the blade just clears the point *a*.

With pencil draw *ae* along the vertical edge of the triangle precisely through the point *a*. *ae* is perpendicular to *ac* at *a* (assuming that the triangle is true).*

Draw *cd* through *c* perpendicular to *ac*, in the same way.

From *a* lay off on *ae* the distance $ae = 9"$, and mark the point *e*.

Slide the T head along the left edge of the board till the upper edge of the blade just touches point *e*.

*To test a triangle: Make a fine point just below the center of the paper, and mark it *a*. Slide the T head along the left edge of the board till the upper edge of the blade clears the point *a* by a quarter-inch. With the triangle to be tested, draw a hair line through the point *a* perpendicular to the T blade. Hold the T blade fast. Turn the triangle bottom up by revolving it about the edge which is perpendicular to the blade. Again draw a perpendicular to the blade through the point *a*, using the triangle in its present position. Any angle between the two lines drawn is double the error in the right angle of the triangle.

Draw a line with the pencil through the point *e*, along the blade and across the paper.

The four lines thus drawn enclose a rectangular space 9"x12". Mark the unlettered corner *d*.

When the plate is finished, *i. e.*, when the drawing on this sheet has been completed, the paper will be smoothly cut with a sharp knife along the four lines just drawn.

As you have done, draw all *horizontal lines* (lines running from left to right) along the upper edge of the blade of the T, while its head is in full contact with the left edge of the board. Draw all *vertical lines* along one perpendicular edge of a triangle while the other is in full contact with the upper edge of the blade of the T, which is in correct position for drawing horizontal lines. See Fig. 1. If the near edge of the board is true and perpendicular to the left edge, vertical lines may be drawn along the T blade, sliding the T head along the near edge.

50. Border Line.—Fig. 2. From the point *a* lay off toward *ac* the distance *ab* = 1". Mark the point *b*.

Through *b* draw the vertical line *bf* (parallel to *ae*).

Lay off upward from *b* on *bf* the distance *bi* = $\frac{3}{4}$ ". Mark point *i*.

From *i* lay off *if* = $7\frac{1}{2}$ ". Mark the point *f*.

Through *i* draw the horizontal line *ih*.

Through *f* draw the horizontal line *fg*.

From *f* lay off *fg* = $10\frac{1}{4}$ ". Mark *g*.

Through *g* draw the vertical line *gh*.

ifgh is the *border line* within which all further drawing on this sheet is to be done. The space between the cutting line and the border line is the *margin*, and is to be left free from marks, except for certain lettering.

51. To Finish a Plate.—With the rubber pencil-eraser (25), remove the pencil lines

from the area bounded by the cutting line (49). If the drawing is grimy, clean it with stale bread (26). Print lightly with pencil the plate number (at the right end of the top border line), the name of the draftsman (at the right end of the lower border line), and the date (at the left end of the latter line). After completing the course in Lettering, the lettering of the plates is to be carefully done with the lettering-pen. Cut the paper with a sharp knife along the cutting line. Use neither a straight-edge (triangle side or T blade) nor a triangular scale, as a guide for the knife.

After completing all the plates in Linear Drawing, bind them into a book with a cover-plate (70).

§ 4. *Plate I: Medium Lines.*

52. Full Lines.—Make dots $\frac{1}{4}$ " apart, dividing the line *if* into 30 equal parts. Through each dot will be drawn a line with the ruling-pen.

The ruling-pen and the water-proof ink now come into use. By means of the set-screw of the ruling-pen, make the distance between the nibs equal to the width of the first line in Fig. 3. Fill the pen with ink (21).

In the rectangle *ifgh*, through the dots on the line *if*, you are to draw a series of 22 horizontal lines with the ruling-pen. Each line is to extend from *if* to *gh*. The first line to be ruled is *fg*.

Following the directions given in 21, rule the line *fg*. Now ask yourself the following questions:

(1) Is the lower edge only of the line ragged, as in Fig. 9? If so, you inclined the pen handle from you while drawing the line.

(2) Is the line ragged on only the upper edge, as in Fig. 10? If so, you inclined the pen handle toward you.

(3) Is the line ragged on both sides, as in Fig. 11? If so, the axis of the set-screw was not perpendicular to the direction of motion.

(4) Does the width of the line vary, as in Fig. 8? If so, you have pressed the pen on the paper or against the blade with a varying force, thus changing the opening between the nibs.

In beginning to draw a line and after the pen has been placed at the starting-point, place the head directly in front of the pen to see that the handle has no slope to right or left. Then place the head in such a position that the eyes are about 10" directly above the upper edge of T blade and about 10" to the left of the pen. With the head in this position the inside faces of the blades are equally visible when the set-screw axis is perpendicular to the direction of motion. In moving the pen to the right to draw a line, the right hand and arm should remain rigid and not swing about the shoulder or elbow as a pivot. Move the body to the right, carrying the hand and arm with it. Do not try to improve an imperfect line by re-ruling it.

Continue drawing full lines until 22 have been drawn, and on completing each examine it as you did the first line. Ascertain, if possible, the cause of each imperfection, and aim to avoid it in drawing each succeeding line. Rule a line by moving the pen at uniform speed.

53. Dash Lines.—Now with the same pen opening draw the next 4 lines like the dash line of Fig. 3. Make the dashes and intervals of the lengths shown there. If necessary, draw the first line in pencil and lay off on it from the left end, first the length of a dash, then the length of the break between dashes; and so on alternately. Then retrace with ink and ruling-pen.

In drawing each segment (or dash) the same rules are followed as when drawing any straight line. The outline of each dash should be rectangular (Fig. 6). To draw the dash: (1) Hold the

pen in the position for drawing, at the beginning of the dash; (2) see that the ink touches the paper; (3) move the pen, as in drawing a straight line, to the right end of the dash; (4) stop the pen; (5) lift the pen vertically from the paper. If these directions are neglected there may result a dash of irregular outline (Fig. 7). The cause of the forked dash may be seen by holding the well-filled pen, handle up, between the window and the eye (Fig. 20).

Draw 4 dash lines.

54. Dot Lines.—The 27th and 28th lines are to be dot lines. Each dot is a very short dash. Use the dot line of Fig. 3 for a model.

55. Dash-Dot Lines.—The last 3 lines are to be dash-dot lines. Use the dash-dot line of Fig. 3 as a model.

Finish the plate (51).

Plate 1 is to be repeated till the character of the lines is satisfactory.

§ 5. *Plates 2 and 3.*

56. Plate 2: Heavy Lines.—Plate 2 is like Plate 1, except that the pen opening and the lengths of dots, dashes, and intervals are to be taken from Fig. 4.

Plate 2 is to be repeated till the work is satisfactory.

57. Plate 3: Fine Lines.—This plate is to be like Plate 2, except that Fig. 5 is to be followed as a model. This plate is to be repeated till the pen-work is satisfactory. Fine lines are more difficult to make well than either of the others, because the ink dries very rapidly in the narrow pen opening. Do not bear down on the pen to start or aid the flow of ink, for this brings the points of the pen nearer together and still farther retards the flow. If the pen makes no mark, or only a

ragged or irregular one, the only remedy (provided the points are properly sharpened) is to clean and refill the pen. This may have to be done every two or three minutes, or oftener on a warm day. For fine lines special pains must be taken to keep the outsides of the nibs perfectly bright while drawing. Patient attention to details will produce good work.

Do not entirely close the opening between the points of the nibs in the endeavor to make fine lines.

§ 6. *Plate 3a: Circles.*

58. Pencil Circles.—Lay out a plate (48, 49, 50). The inner rectangle is to be used for drawing circles with pen and pencil.

Follow the directions given in 37–40.

Spread the compass legs till the knuckle joints are about 2" apart, and bend the knuckle joints to make the needle leg and pencil leg parallel to the bisector of the angle between the compass legs. Fig. 22 shows the needle and pencil legs so bent.

Select any point well within the border line of the paper for a center, at which place the point of the needle leg. Holding the handle between the thumb and forefinger (Fig. 22), so that the needle leg is about perpendicular to the paper, let the pencil point come in contact with the paper. Rotate the compass about the needle point as a pivot, causing the pencil to trace a circumference. Bear down on the pencil leg only enough to make the finest possible distinct line.

With the same center, but with varying radii, draw many circles. So manipulate the compass that the needle mark at the circle center remains almost invisible. Sharpen the pencil as soon as it becomes dulled, so as to make all the lines have the same appearance.

From new centers, draw other sets of circumferences. This work is to be continued no longer than necessary to give the student familiarity with the compass.

59. Ink Circles.—Loosen the clamp-screw which holds the pencil leg; remove the pencil leg; insert the pen leg; tighten the clamp-screw gently. Bend the pen leg at the knuckle joint. Set the pen, by means of the set-screw, for medium lines (Fig. 3). Fill the pen with ink (22). Retrace in ink those circles which have been drawn with the pencil.

Examine the character of the first ink circle drawn in connection with Fig. 17. If the line is smooth on both edges, the pen points touch the paper equally. If the line is rough on the inside, bend the pen leg outward about its knuckle joint to bring the inner nib of the pen into contact with the paper. This changes the radius, and if a circle of the radius of the first one is to be drawn next, the points must be brought inward by closing the compass legs slightly. If the line is ragged on the outside, bend the pen leg inward about its knuckle joint to make the outer nib touch the paper. This may require a readjustment of the compass legs.

Repeat, with ink, all the circles which were drawn in pencil, studying each ink circle, as it is made, in connection with Fig. 17.

Practice with the pen set for medium, heavy, and fine lines. Make circumferences with dash, dot, and dash-dot lines (Figs. 3, 4, 5, 18).

Notice that the knuckle joints must be rebent for any considerable change in circle radius, *i. e.*, in the distance between the points.

§ 7. *Plate 4: Accurate Construction.*

60. To Construct the Square.—Lay out the plate (48–50). Sharpen the pencil (17). The pencil lines should be as fine as it is possible to make them and have them distinct by diffused light. The determined points should be marked lightly with the needle-point, and a small circle be drawn with pencil around each, that it may be quickly found when wanted. Break the pencil lines at these circles. See Fig. 12.

The four corners of the inner rectangle are named *fghi* as in Fig. 2.

Now look at Fig. 12. On the line *ih* from *i* lay off *ij* = $\frac{1}{8}$ ". Mark *j*. At *j* draw the vertical *jl*. Lay off *jk* = $\frac{1}{8}$ ". Mark *k*. Lay off *jl* = $7\frac{3}{8}$ ". Mark *l*. *kl* is the left side of the required square *jlmn*.

Here insert a piece of HHHHHH lead in the pencil-point of the compass, and sharpen it to a chisel-point, the edge of which is tangent to the circle to be drawn. The finest hair lines only, are to be drawn with the compass, which requires that the chisel-point be kept sharp, and that the lines be drawn with little or no pressure brought to bear on the pencil-point during the rotation of the compass.

Construct the square thus: With the center *k*, radius $4\frac{1}{2}$ ", draw a very fine pencil arc *CD* with the compass. With center *l*, and with exactly the same radius as before, draw arc *EF* cutting *CD* at *G*. With the pencil draw a small free-hand circle about *G*. With centers *k* and *l*, with the radii = 7", draw the arcs *HJ* and *KL*, which intersect in point *t*. Draw a line precisely through *G* and *t*. The line *Gt* bisects the line *kl* and is perpendicular to it at the point *M*. *Ml* should equal *Mk*. If it does not, the work is inaccurate and must be repeated.

With center M , radius = Mk , with the compass draw pencil arc cutting Mt in the point o . o is the center of the square $jlmn$.

Draw the diagonals lon and kom . From o as center, with radius = ok , describe an arc cutting lon at n . Similarly find m . Draw kn , nm , and ml , thus completing the square. The sides of the square should be equal. If they are not, the work must be repeated.

61. To Bisect an Angle and To Inscribe a Circle.—With compass, with radius = $4\frac{1}{2}"$, and with k as center, draw arc uv , cutting ko at u and kn at v . From u and v as centers, with radii = $2\frac{1}{2}"$, draw two arcs to intersect in the point w . Line wk bisects angle okn . Similarly construct the bisector ox of angle kon . Bisectors wk and ox intersect at x .

From x as a center inscribe a circle in the triangle. For the final adjustment of the compass opening, use the hair-spring adjustment. In the same way inscribe a circle in each of the three remaining triangles.

Each circle should be precisely tangent to the three sides of its triangle. If any circle is not so tangent, the work of finding the circle center must be repeated.

Join the circle centers x , y , z and A by straight lines to form a square. With o as center inscribe a circle in this square. If this circle is not precisely tangent to the four sides of the square, the whole figure must be repeated.

62. To Divide a Line Into Equal Parts.—Parallel to and $\frac{1}{4}"$ to the right of mn draw ps . Parallel to and $\frac{1}{8}"$ to the left of gh draw rq . Prolong lm to meet ps in s and qr in r .

Divide pq into 5 equal parts. To do this measure with the scale the distance pq . Divide this distance by 5, and open the bow divider (Fig. 24) to take in on the scale this quotient. Now begin at p and step off carefully (without pricking the paper) toward q with the bow divider set as above, 5 steps. If the last step ends precisely at q , the divider has the proper opening. If

the last step over-reaches or falls short of q , change the width of divider opening by means of the adjusting screw by one-fifth of the discrepancy. Step off the distance pq with the new opening. If there is still a discrepancy, readjust for one-fifth of it. This must be continued till there is no discrepancy. When the divider is finally set to exactly one-fifth pq , the stepping is repeated and the end of each step is marked by a prick mark or pencil mark. Mark the points of division with great precision.

Similarly divide ps into 7 equal parts.

Through the points of division on pq draw (with very sharp pencil) lines parallel to ps (see Fig. 21).

Through the points of division on ps draw lines parallel to pq .

These two sets of lines cut the rectangle $pqrs$ into equal rectangles.

Now draw straight lines to join points of division on the four sides of the rectangle $pqrs$, as shown in Fig. 12. The lines form the diagonals of the small rectangles. The diagonals should cut precisely the corners of the rectangles. If they do not, the work must be repeated.

63. To Ink Plate 4.—Set the ruling-pen for fine lines (Fig. 5) before filling it with ink. Set the nibs to give the smallest *visible* opening; do not make the nibs actually touch each other. Fill the pen, and retrace, *in the order named*, the following lines:

- (1) The four sides of the square $klmn$.
- (2) The two diagonals, km and ln .
- (3) The four equal circles.
- (4) The square $xyzA$.
- (5) The circle inscribed in the small square $xyzA$.
- (6) The diagonal lines of the figure $psqr$.

(7) The vertical and horizontal lines of the figure psqr. These must not be drawn crooked to pass through intermediate points.

(8) The border line, with pen opened to draw medium lines (Fig. 3).

Finish the plate (50). This plate is to be repeated until it is satisfactory.

§ 8. *Plate 5: Irregular Curves.*

64. To Use French Curve.—On a piece of drafting-paper, draw with a hard pencil some smooth, free-hand curves or flourishes of any form, and retrace these with a soft pencil, using the French curve as a guide. To use this guide, find by trial a portion of the guide that will just fit a small portion of the free-hand curve at one end, as at *ab* in Fig. 19. Retrace the segment *ab* with a soft pencil, using as a guide that portion of the French curve which fits the segment *ab*. Then seek that portion of the French curve which will fit the next segment of the free-hand curve. This process is continued till the whole curve is retraced.

In retracing a free-hand curve with the ruling-pen, the pen must be twisted in the hand as it moves along the guide, in such a manner that the axis of the set-screw is continuously perpendicular to the direction of motion. The pen must be held perpendicular to the paper.

When drawing heavy ink lines leave a minute break between segments, to avoid blots. Do not use a blotter (46). When the ink is dry on the segments they may be joined with lettering- or ruling-pen.

In order that the curve may be continuous from one segment to the next through the junction, it is necessary that the tangents (imaginary) to the two adjacent segments at the junction point lie in the same straight line (Fig. 16). If these tangents do not form one line the curve is broken, not continuous.

65. To Construct Plate 5.—After a little practice with the French curve, lay out Plate 5 (48, 49, 50).

See Fig. 15. The point **n** may be determined by drawing diagonals **fh** and **ig**. Draw **lm** and **jk** to divide the rectangle **ifgh** into four equal parts, and intersect at **n**.

Draw radiating lines to divide each quadrant at **n** into four equal parts (61). Letter the radiating lines as in Fig. 15.

Lay off on **ns** from **n** the distance $n1 = \frac{1}{8}"$. Make $n2 = \frac{2}{8}"$; $n3 = \frac{3}{8}"$; $n4 = \frac{4}{8}"$; and so on, till the last point falls outside of the border line.

Through points **1, 2, 3, 4, 5**, etc. draw very lightly with pencil a smooth, free-hand curve. (For this it may be helpful to draw pencil circles, from **n** as center, through the points **1, 2, 3, 4, 5, . . .**.)

With the ruling-pen set for medium lines (Fig. 3), retrace this curve, using the French curve as a guide.

Retrace border line, **ifgh**, with ruling-pen set for medium lines.

If the curve **12345 . . .** shows any or all of the faults of Figs. 8, 9, 10, 11 and 16, it must be redrawn.

Finish the plate (51).

CHAPTER III.

A COURSE IN LETTERING.

§ 9. *Required Work in Lettering.*

66. Materials Required for Lettering.— Use black, water-proof drawing-ink. For small letters use Gillott's 404 pen, and for large letters (as in titles) use Leonardt's 506 F or other ball-pointed pen. The lettering-paper provided with this book is ruled by horizontal lines 1 mm. (millimeter) apart. Every tenth horizontal line (heavy), beginning with the heavy line at the top of the sheet, is to serve as top guide line for a line of lettering, in all the work up to the first plate of titles. I-guides (72) are ruled for both Vertical and Inclined lettering.

67. Preliminary Practice.— SHEET I. Read and follow step by step the directions given in 46 and 73.

Line A. Draw vertical strokes extending from guide 3 to guide 6 (72), one after another, to fill this line.

Line B. Draw vertical strokes, each of which begins at guide 1 and ends at guide 6.

Line C. Draw horizontal strokes about 3 mm. long.

Line D. Draw strokes 3 spaces high, standing on guide 6, sloping 45° to the right (estimating the angle).

Line E. Make 45° strokes sloping backward, 5 spaces high, and standing on guide 6.

Line F. Draw *o* and *O* repeatedly (74, 78).

Line G. Draw the top and bottom thirds of *o* and of *O*.

Line H. Draw the top and bottom thirds of *o* and *O* and add a reverse stroke to make of each fractional *o* and *O* an *s* and *S* respectively (80).

The rest of the sheet will be devoted to practising those strokes given above which have been made with the least success.

SHEET II.—Practise making the Vertical lower-case letters, following carefully the directions under §§ 10 and 11. Do not try to make the strokes as heavy as those in the model. After a little practise on the individual letters, print words and thus fill out the sheet. Do not repeat a letter more than six or eight times consecutively, but return to it after making others.

SHEET III.—Practise Vertical capitals, following directions under §§ 10 and 11. After becoming familiar with the individual letters, print words till the sheet is finished.

SHEET IV.—Practise Vertical numerals (89), at first 5 spaces high, and then 3 spaces high. On the lower half of the sheet practise fractions and mixed numbers.

68. Plates 6 and 7.—For *Plate 6* copy the text in this book, beginning with § 10. Use Vertical capitals and lower-case letters as they occur in the text. This plate is to be repeated until the lettering is satisfactory. Print the plate number and maker's name on the lettering plates as on the plates of drawing.

For *Plate 7* copy the text of this book, beginning with 92. Use Vertical lower-case letters and capitals as they occur in the text. Use figures for all the numerals. Repeat this plate till it is satisfactory.

69. Plates 8 to 17: Titles.—The following plates are to consist of titles, one to each plate. Use Vertical letters and follow the directions given in § 12. Make the largest letters of each title 9 mm. high, using 506 F pen. The heights of letters in the less important words, and of the

spaces between lines, will be determined as far as possible by the suggestions given under 90, and the Figs. 36, 37, 39. The individual letters of each title are to be of the style used on the preceding lettering plates. Each line of a letter is to be made with a single stroke of the pen. No shaded letters are to be made.

Each title is to be symmetrically located on the plate.

Each plate is to be repeated till the work is satisfactory in all respects.

The text to be used for each title is given below:

Plate 8. Winnemucca, Nevada, surveyed by W. H. Olds, scale $1''=1000'$. 1901.

Plate 9. Tail-stock of wood-lathe, scale $6''=1'$. John Smith.

Plate 10. 18" shaft-hanger, scale half size. August Green.

Plate 11. Pedestal bearing of 20" x 36" Corliss engine, scale $3''=1'$. Wm. Allgood.

Plate 12. Profile of Hale street sewer, between Jay street and Chase avenue.

Plate 13. South part of Big Basin reservation, Santa Cruz County, California, surveyed by Thos. Arnold; scale 1 inch=500 feet, equidistance 10 feet. 1901.

Plate 14. Preliminary survey Los Trancos railroad, Mayfield to Portola, Santa Clara County, California; George Thompson, locating engineer; scale $1''=200'$; contour interval 5 feet. 1901. (This title is to be made as for a map to be filed in the Chief Engineer's office.)

Plate 15. (This title is to read the same as that for Plate 14, but is to be printed on this plate as for a map to be filed with a public officer.)

Plate 16. Nevada & Colorado railroad; wooden trestle over Humboldt river; scale $1''=4'$. 1901.

Plate 17. Proposed water supply system for Banning, Cal.; location and sizes of mains; Chauncey Monday, Civil Engineer; scale $1''=400'$. 1900.

70. Final Work on Plates.—*Cover-Plates.*—Lay out a plate on the white drawing-paper. Ink the border line.

In the middle of the plate print “Linear Drawing” in the style used for the lettering plates, making the capitals 9 mm. ($\frac{3}{8}$ ”) high. Print the name of the draftsman in the same style with capitals and long lower-case letters 6 mm. ($\frac{1}{4}$ ”) high, within $\frac{1}{2}$ ” inch of the lower and left-hand edges of the plate. Similarly print the date in the lower right-hand corner of the plate, just above the border line.

The cover-plate for the lettering plates is to be lettered in every way like that described above, except that “Lettering” will take the place of “Linear Drawing.” The lettering cover-plate will be of exactly the size of the lettering plates.

Binding the Plates.—The plates of Linear Drawing are to be arranged in proper order, beginning with the cover-plate, and neatly bound by fastening together with McGill fasteners at the left end, where is the widest margin. The lettering plates, including their cover-plate, are to be bound in like manner.

§ 10. *Vertical and Inclined Lettering. Preliminary.*

71. Directions of Letter Stems and Axes.—The straight strokes of the letters *a b d h i j l m . . . I . . .* and the long axes of the letters *o e s o . . . A M V . . .* of the same style are parallel, and their common direction will be referred to as the *I-slant* of that style.

72. Guide Lines: Horizontal and I-Guides.—In Fig. 34 eight equidistant horizontal guide lines have been drawn and numbered from the top downward. Nos. 1 and 6 limit the capitals and figures and certain lower-case letters, as *b d . . .*. Nos. 3 and 6 limit the lower-case letters *a c e m . . .* and the bodies of *b d g . . .*. No. 8 limits the tails of *g j p q y*. The intermediate

guides are drawn for convenience in describing the details of certain letters. In lettering drawings the draftsman usually pencils only the main guides, 1 3 6. *I-guides* are those drawn to control the direction of those strokes which have the I-slant (71). I-guides are shown drawn for *o a b*, Fig. 34 (left end) and for *a o s* in Fig. 31 (left end). It will be noticed that the direction of the I-guide is the same as that of the letter I for a given style of lettering. For the Inclined lettering discussed in this book, I-guides are drawn to have a slope of 2:5 (2 horizontal to 5 vertical). On the lettering-paper which accompanies this book two sets of I-guides have been ruled for the convenience of the beginner, one vertical and the other with the 2:5 slope.

73. Individual Pen Strokes.—Figs. 30–34. All the strokes of each letter should be of the same width. Follow carefully the instructions under 46. It is a good plan to practise drawing straight lines slowly with constant pen pressure till lines can be made as uniform in width as those drawn with the ruling-pen. It will be found that even an unsteady hand can make fair lines after a little practice. Steady the pen if necessary by holding the left hand on the paper with the left first finger extended and pressed against the right thumb nail. Rapid strokes are smoother but cannot usually be controlled to correctly form the letters.

The order of making the strokes of each letter is given by small numerals, and the direction of each stroke is indicated by an arrow. Observe carefully the point of beginning and the point of ending, as well as the direction of each stroke as it is copied, *e. g.*, the top of the stem of *b* should be precisely on the top guide—not below it, not above it. Make the top and bottom curved strokes of letters precisely tangent to the proper guides: *o c e . . .* touch, but do not overlap their top and bottom guides. Guard against ending a stroke, as at the bottom of *c e*, with a flip of the pen, as is customary in writing.

Horizontal and oblique strokes require more pains than vertical.

74. O as Model for Curve Forms.—Almost every curve of the letters and figures of the Vertical and Inclined styles of lettering may be considered as embodied in the letter *o* or *O* with very little error and with great advantage to the beginner in the saving of time and mental effort. This letter should be practised till it can be well made before the other letters are taken up. In this practice it should be made circular. When making a letter which involves a part of *o* (or *O*) so large as to require its first being put in with pencil (as in titles), it is well to lightly pencil the whole *o* (or *O*) in order to smoothly connect the various strokes of the letter.

75. Differences Between Vertical and Inclined Lettering.—These styles of lettering are so near alike in detail (their great difference being due to the difference in the direction of their I-guides, 72) that the latter can with little error be considered as the former alphabet with its letters canted over uniformly. In the following section each numbered paragraph starts off with a rather full description of a group of letters or numerals in the Vertical style. In every case the description is to be taken as applying to the Inclined style, except as noted at the end of the paragraph under the sub-head "Inclined."

76. Widths of Letters and Figures.—The beginner usually makes letters too narrow. It is well to try to make the letter *o* as wide as high (circular), in practising.

Taking the width of *o* as unity: *m* is $1\frac{1}{2}$, *w* is $1\frac{1}{2}$, *r* is $\frac{3}{4}$, *t* is $\frac{2}{3}$, and all other lower-case letters (except *i* and *l*) are each as wide as *o*.

Taking the width of *O* as unity: *A* is $1\frac{1}{5}$, *M* is $1\frac{1}{5}$, *W* is $1\frac{3}{5}$, *J* is $\frac{4}{5}$, and all other capitals (except *I*) have each the width of *O*.

Taking the width of *O* as unity: the width of *4* is $1\frac{1}{4}$, and the other numerals (except *I*) are each as wide as *O*.

These are rough rules, but will be found sufficiently precise for freehand lettering.*

77. Spacing Letters and Words.—The letters in a word should be so spaced as to present as nearly as possible a uniform distribution of black and white. For all ordinary lettering the spacing is done by the eye, which should be trained by carefully studying the spacing of letters of words printed in large type, as those on the title-page of a book.

In reading a book printed in type to which you are accustomed, the eye usually takes in a number of words at a glance; the longer the words the smaller the batch, and an unfamiliar word may require undivided attention, but it is seldom that the individual letters are scrutinized. If the letters of a word are set too far apart, a conscious effort is required to take in the word without noting the individual letters. Less effort is wasted in reading words whose letters are crowded more than usual. Beginners should try to place the letters of a word as near together as is possible without having them actually touch, in order to overcome their strong tendency to make the letters too far apart.

A J and *L* are wider at the bottom than at the top, while the reverse is true of *F P T V W* and *Y*. Where we have in a word the pair *AJ LJ LA FV PV* or *WY . . .*, there must be more white space between the letters of the pair than between two adjacent letters usually. But where there occurs the pair *FA VA LT . . .*, its two letters can be interlocked, the projecting part of one encroaching on the gap in the other. Notice in *NEVADA*, Fig. 36, that the right branch of *V* overtops the left branch of *A*. If the spacing of the letters in this word had not been done by eye, but by allotting to each letter the same amount of space (as is often done in making titles), there would be a noticeable gap between *V* and *A*, thus: *NEV ADA*. (See 92 for method used in constructing this title.)

* For complete and accurate dimensions of the letters of several styles of alphabets the reader is referred to Jacoby's "Plain Lettering" (*Engineering News*, N. Y., \$3).

The distance between words in a sentence should be the width of *o* for lower-case and *O* for capital letters, but these distances may be increased to a certain extent in a title.

§ 11. *Details of Letter Construction.*

78. Details of Lower-Case *o*. *Vertical.*—Fig. 34. This letter may be made with one stroke, beginning and ending at the top, but usually it is best to make it in two strokes, as shown. Unite the two strokes carefully, to avoid blots at the joints. The long axis of *o* has the I-slant (71). When about to make *o* with a pencil, pencil lightly an I-guide (72) for its axis. The width of *o* should usually be taken slightly less than its height (76).

Inclined.—Fig. 31. The above description applies to the inclined *o*, remembering that for this style the I-guide is inclined instead of vertical.

79. Details of *a b d g p q*. *Vertical.*—Figs. 33, 34. Each of these letters consists of the letter *o* (78) and an I-slant (71) stem, which in the case of *g* turns to the left at guide 7 (72) to form a curve one space high, like the bottom of *o*. The beginner should make the *o* first and add the stem till he can fairly form each letter, after which he will in the case of *b* and *p* make the stem first. The *o*-portion of each letter should be made nearly as wide as high; and if the beginner has the common tendency to make these letters too narrow, he should overcome it by trying to make them too wide for a time. These letters may be made with the *o*-axis inclined to the right, thus: *o*.

Inclined.—Fig. 31. The above, with the exception of the last sentence, applies to Inclined lettering. However, the Inclined letters will be more satisfactory if the axis of the *o*-part of each has a slant of 45° instead of the I-slant (71); and *b* and *p* are further improved by omitting the extreme left point of the *o*-part.

80. Details of c e s. *Vertical.*—Figs. 33, 34. **c** is **o** with a gap in its right side. The beginning of the stroke extends farther than the end, to the right. **c** may be made in two strokes or in three, as well as in one; but whatever the number, each stroke must be made throughout its length with deliberation.

For **e** make **c** with the right upper part produced down to the horizontal stroke, which is added at the mid-height of the letter. A variation in the position of the cross-bar is shown in *e* of Fig. 31.

The top and bottom of **s** are like the corresponding parts of **o**. The reverse curve is drawn to smoothly connect the top and bottom curves, and pass a little above the center of the letter, which otherwise will look top-heavy. The order of strokes should be that which produces the best **s**. In capital **S** (Fig. 33) another order of strokes is indicated. A third order is: Reverse curve first; top, second; and bottom, last. A fourth method of construction is: Make top curve and upper half of reverse curve with one stroke; imagine (or draw, if using pencil) an I-guide (72) passing through the lower end of the stroke just made; and beginning at this point, finish the letter with one stroke so made as to balance on the I-guide.

Inclined.—Figs. 30, 31. The above applies to *c e s*. It is usual to make the bar of *e* oblique.

81. Details of h m n r u. *Vertical.*—Figs. 33, 34. **h** is like **n** except that the first stroke of **h** extends to the top guide. **m** is like **n** with its curve and right, straight stroke repeated. The letter is improved by having the curves made sharper, giving a narrower letter (76). For **n** make the left stroke, giving it the I-slant (71); then draw the curve as if for the upper half of **o** (with I-slant axis); and add the short stroke parallel to the first, joining it smoothly with the curve. After a little practice the curve and short stroke may be combined in one, but bear in mind while making this that there are two distinct portions, a curve and a

straight line, with a fixed point of tangency. It is a good plan to stop the pen momentarily at the end of the curve before going on with the straight line, otherwise the right side of the letter is apt to be a weak curve. **r** is like **n** omitting the right down stroke. **u** may be considered as two strokes (having the I-slant) smoothly connected by a curve which is the lower half of **o**; but it will be found easier to flatten the curve, bringing the straight strokes down a little farther, as shown in Fig. 33.

In making **h m n r** care should be taken that the curve leaves the first stroke without filling the notch with ink. This may be avoided by flattening the curve, so that it leaves the first stroke sharply instead of at a tangent.

Inclined.—Figs. 30, 31. The preceding applies to this style of letter.

82. Details of f i j l t. *Vertical.*—Figs. 34, 33. **f** is formed by adding a short curve to the top of **t**. When the top curve and stem are made at one stroke, stop the pen for an instant at the end of the curve on the second guide to get a fresh start on the straight part, and thus avoid a crooked stem. **i** has the I-slant (71). The dot is a very short dash placed on guide 2 and in the prolongation of the stem. To make **j**, continue the stem of **i** downward one space, and add a curve like the bottom of **o** to occupy the bottom space. If the letter be made in one stroke, it is well to guard against making a crooked stem by stopping the pen for a moment at the beginning of the curve. **l** is straight, begins at the top guide, and has the I-slant. The stem of **t** is straight, has the I-slant, and, unlike any other letter, begins on guide 2. The cross-piece should be a full-width stroke, without blot, truly horizontal, and with its upper edge precisely on guide 3. It is well to let the main stroke dry before putting on the second, if a blot cannot otherwise be avoided.

Inclined.—Figs. 31, 30. The foregoing description applies also to this style.

83. Details of k v w x y z. *Vertical.*—Figs. 32, 33, 34. For **k** take care to make the second and third strokes straight, of full width, and without blots at the meeting points. The second stroke meets the first at guide 5 and makes with it a 45° angle; and the third meets the second at guide 4. The two strokes of **v** make equal angles with an I-guide (72) through their point of meeting, and their axes should meet precisely on guide 6 that the point of the letter may be neither wider nor narrower than a single stroke. When a **v** of large size is to be made, follow directions given for capital **V** (88). **w** is formed of two rather narrow **v**'s. Make strokes 2 and 3 meet as neatly as strokes 1 and 2. For **y** make **v** and prolong its right side to guide 7, and add a flat curve tangent to the stem and to guide 8. The two strokes of **x** make, with the I-guide through the center of the letter, equal angles a little larger than the corresponding angles of **v**. It requires some special effort to put in the second stroke without blotting the first at the meeting point. If this cannot be done, the second stroke can be added after the first has dried, or a break may be made in the second stroke just sufficient to clear the first. **z** is shown made with three strokes. Strokes 1 and 2 should be truly horizontal, of full width, and without ragged edges, and the third stroke should meet these sharply. After enough practice the letter may be made with one stroke, but at the risk of picking up paper fibres at the turns and thus blotting the notches.

Inclined.—Figs. 30, 31. The foregoing description applies here.

84. Details of Capitals O Q. *Vertical.*—Fig. 33. **O** is best made in two strokes, which must be smoothly joined. The letter is symmetrical with respect to an I-guide (72) through its center. **Q** is formed by adding the short oblique stroke cutting the lower right quarter of **O**.

Inclined.—Figs. 30, 31. The preceding description applies to this style.

85. Details of C D G J S U. *Vertical.*—Figs. 34, 33. **C** is similar to lower-case **c**

(78). The right side of **D** is the right stroke of **O**, and is connected by short horizontal strokes to the first stroke, which has the I-slant (71). Though better made distinct at first to impress the student with the correct form of the letter, the three strokes 2, 3, 4 are usually combined in one by a skilful letterer, who nevertheless must think of the strokes as three while he is making them as one. To form **G**: make the first stroke as for **O**; the second stroke begins at the junction of the I-slant axis of the letter and guide 3, extends horizontally half the width of the letter, and turns sharply downward to form the right lower quarter of **O**. **J** consists of a stem having the I-slant which connects smoothly at guide 5 with a curve which is tangent to guide 6 and rises to guide 5. **S** and **U** are respectively similar to **s** (78) and **u** (79).

Inclined.—Figs. 30, 31. The foregoing description applies here.

86. Details of B P R. *Vertical.*—Figs. 33, 34. Putting in a third horizontal stroke at the bottom and a (slightly larger) second half-**O** below the first, converts **P** into **B**. The curve of **P** is the right half of lower-case **o**, and is smoothly connected to the I-slant stem by two short, horizontal strokes. It is helpful to make the short strokes separately as shown; though the letter can be well made by combining the last three strokes in one if mentally they are kept distinct. **R** is made by adding an oblique stroke to **P** at the right end of stroke 3.

Inclined.—Figs. 31, 30. The foregoing description applies here.

87. Details of E F H I L T. *Vertical.*—Figs. 33, 34. In these letters special pains must be taken with the horizontal strokes. Add a horizontal stroke at the bottom of **F** to form **E**. The top stroke is slightly shorter than the bottom. The lower horizontal stroke of **F** is shorter than the other by a third, and lies a little below guide 3. The horizontal stroke of **H** is just above the center. **I** is a single stroke whose direction is called the I-slant (71) of this style of lettering. To avoid mistakes where **I** might otherwise be taken for lower-case **l** or the numeral **1**, add

very short, horizontal strokes to **I** at top and bottom, as in ordinary print. Add a horizontal stroke to the right of the bottom of **I** to form **L**. The horizontal stroke of **T** is bisected by the I-slant stem.

Inclined.—Figs. 30, 31. The preceding description applies here.

88. Details of A K M N V W X Y Z. *Vertical.*—Figs. 33, 34. Special pains must be taken to make all the horizontal and oblique strokes straight and full width, and to give each its correct direction. The two sides of **A** make equal angles with the I-guide through the peak. Make a dot for the bottom of each side stroke. Imagine (or draw, if working with pencil) an I-guide (72) midway between these dots. Draw the side strokes toward the two dots from the intersection of the I-guide with the top horizontal guide. The third stroke is just below guide 4. In **K** stroke 2 meets stroke 1 at guide 4; stroke 3 meets stroke 2 at guide 3. Stroke 3 extends to the right farther than stroke 2. For **M** make the two I-slant, side strokes; midway between these and on guide 5 place a dot, toward which draw the sloping strokes. **M** is one-fifth wider than **O** (84). In **N** take pains to have the third stroke axis straight and cutting the side-stroke axes precisely on guides 1 and 6. The method given for constructing **A** applies to **V**. **W** consists of two rather narrow **V**'s. **X** is similar to **x** (81). If making the letter with a pencil, first draw an I-guide through the letter center by which to gage the slopes of the strokes; or draw the two sides of the quadrilateral which encloses the letter space, and draw the strokes as diagonals of this figure. The top branches of **Y** make equal angles with the stem, which has the I-slant (71), and meet it slightly above guide 4. **Z** is similar to **z** (81).

Inclined.—Figs. 30, 31. The foregoing description serves here also.

89. Numerals and Fractions. *Vertical.*—Figs. 33, 34. *Numerals* are of the same height as capitals except when occurring in simple fractions. Zero is the same as capital **O**. The figure

1 is a straight, I-slant line usually, but a short slanting stroke is added at the left of the top when it might otherwise be taken for capital **I** or lower-case **l**. The loops of **2 3 5** are preferably portions of the lower-case **o**, though they are also shown as portions of an *o* whose axis has a 45° slant. The loop of **2** is also shown as based on the upper loop of **8**. The left stroke of **6** and the right of **9** are respectively the left and right halves of **O**. The right stroke of **6** and the left of **9** are the corresponding parts of the Vertical lower-case **o**. These figures are also shown with the axis of the loop tilted 45° to the right. **8** may be considered as two Vertical, lower-case **o**'s, one above the other, the lower slightly larger than the upper; or as the letter **S** with the left and right openings closed. The bottom of the **7** is on the I-guide which passes through the middle of the upper stroke.

The denominator and numerator of a *fraction* are each as high as the lower-case **o**. The numerator stands on guide 3 and extends one space above the top guide. The denominator extends from guide 4 to guide 7. The bar between numerator and denominator should be a full-width stroke, truly horizontal, and midway between guides 3 and 4.

Inclined.—Figs. 31, 33. The preceding description applies here.

§ 12. *Titles.*

90. Arrangement and Proportions of Parts of a Title.—The title of almost any text-book furnishes a model for the arrangement and relative proportions of the various parts of a title. The relative prominence of the parts of a title of a working drawing should correspond to their relative importance to those by whom chiefly the drawing is to be used. The most prominent words should be those which will most probably be held in mind by the chief user when searching for this

drawing. Figs. 36, 37, and 39 show three simple titles. At the side of each are small numerals and brackets which give the relative heights of letters and distances between lines of letters. Beginning at the top, Fig. 36: "Winnemucca" is 3 units high; the space between "Winnemucca" and "Nevada" is 2 units; "Nevada" is 2 units high; the space below "Nevada" is 3 units, and so on.

91. Common Faults in Titles Made by Beginners.—The beginner is apt to produce titles which have one or more of the following faults:

(1) The heights of letters in the different parts of the title are incorrectly proportioned.

(2) The spaces between horizontal lines of letters are not well proportioned as to each other and as to the letter heights.

(3) The paper surface is injured, so as to make neat ink lines impossible, by indenting the paper with the pencil, and by the hard erasing which is necessary to remove such heavy-handed pencil work.

(4) The horizontal lines of letters are not centered on the vertical center line which has been penciled.

(5) The spacing of letters in words, or the spacing of words, is incorrect.

(6) Individual letters are incorrect: (a) stems of letters are not made all precisely vertical (for upright lettering) or of the same slant (for inclined lettering); (b) strokes which ought to be truly horizontal are not so made; (c) individual strokes are made with varying pen pressure; different strokes of a letter are made of different thicknesses; and some letters are made heavier than others.

As a rule the student's titles are less satisfactory than his ordinary lettering, because long strokes are harder to make than medium ones, and imperfections which are barely noticeable in medium letters may be prominent in large ones. Also it will be found more difficult to make very small letters than medium-sized ones of the same quality.

92. To Construct a Title.—(1) Write out the title, grouping the words as they are to appear on the drawing (106).

(2) Decide on the position which the title is to take on the drawing (106).

(3) Draw a vertical line through the middle of this space with a sharp 6-H pencil.

(4) Decide on the height of the letters to be used in the principal word or words of the title (106). From this height determine the heights for the letters in the other words, and the widths of spaces between horizontal lines of letters. Lay off these distances in proper order on the center line, to determine the positions of the horizontal guide lines (72), which are now to be drawn lightly with a sharp 6-H pencil (Fig. 36). If necessary for the proper proportioning of the individual letters, draw intermediate guide lines (Fig. 31).

Also rule lightly in pencil, across the spaces which are allotted to the lines of lettering, a series of vertical lines (if for Vertical lettering) or slant lines (if for Inclined lettering). These lines may be spaced by eye somewhat less than one inch apart.

(5) Near and parallel to the edge of a piece of writing-paper, rule two pencil lines spaced apart the height of the letters in the first line of the title. (Time will be saved by cutting a sheet of ruled lettering-paper into strips for this purpose.) Using these lines as guides, print with pencil the letters of the first line of the title, giving special attention only to the widths of letters and of the spaces between them (76, 77). The proportioning of letters and spaces is done here by eye for letters of ordinary size.

Mark the middle point of this line of letters.

Place this paper on the title space so that the marked middle point of the line of printed letters is on the vertical center line of the title, and the line of printed letters lies just above the guide lines drawn for them on the title space.

(6) With pencil not too sharp, and pressed very lightly on the paper, begin at the left end and copy, printing each letter vertically below its model. Give attention to the details as well as to the spacing of the letters. (Direction 6 may be omitted by good letterers on small letters.)

(7) Proceed as above in constructing each of the succeeding lines.

(8) Correct any apparent imperfections in the lettering.

(9) If the desired thickness of the lines of a letter can be made with one stroke of the lettering-pen, without undue spreading of the nibs, the penciled letters may be retraced at once in ink with the lettering-pen (46, §§ 10, 11).

(10) If the lines of some of the letters are to be heavier than can be well made with one stroke of the bluntest pen at hand, outline these letters with pencil. With a medium lettering-pen, retrace the outline in ink. Then erase (after the ink outlines are thoroughly dry) the pencil lines in the vicinity of these outlined letters. Fill in the outlines with ink, using a small water-color brush or very blunt pen which is manipulated so as to barely touch the paper.

If, in filling an outline, too much ink drops from the pen at any part of a letter, the surplus is removed by deftly touching it with the tip of a small piece torn from the corner of a blotter.

CHAPTER IV.

INTRODUCTION TO DRAFTING.

§ 13. *The Paper and the Scale.*

93. Drafting consists in combining lines and letters to represent objects and operations. It is necessary to give as much attention to each line of the drawing of an object, after its position has been determined, as was given to drawing the individual lines of Plates 1, 2, 3, 4 and 5. It is important that the student constantly review and act upon the suggestions given in the first three chapters until he properly cares for and correctly uses his instruments and materials through force of habit.

In order to be able to make a good engineering drawing of an object, it is necessary to have, besides skill in making lines and letters, some acquaintance with common drafting practice and an engineering knowledge of the object. This chapter is devoted to a few of the usages and conventionalities of drafting.

94. Choice of Paper.—Engineering drawings are, for most part, of two classes: (1) drawings which either are not to be duplicated, or are to be duplicated by means of some photographic process; (2) drawings which are to be duplicated by tracing and blue-printing.

(1) Drawing-paper is used for the first class. Hot-pressed paper is used for fine-line drawings; cold-pressed is used for the ordinary range of lines, as in topographic mapping. The rough-grained surface is used for large-scale, heavy-line work. Both medium and rough surfaces

are suitable for water-color drawing (for which the paper must be stretched, as explained in 97). Wall maps, record maps, and all drawings of this class which are intended for severe use, should be drawn on mounted paper.

(2) In some offices simple drawings are penciled directly on the tracing-cloth and then inked. Commonly, detail-paper is used for the original pencil drawing, from which a tracing is made.

95. To Draw to Scale.—The *scale* of a drawing is the relation between distances on the drawing and the corresponding dimensions of the object. Thus we say the scale of a certain map is $\frac{1}{2400}$ (called a representative fraction), or $1''=200'$, or 200 feet to an inch. Of a certain machine drawing we say the scale is $\frac{1}{4}''=1'$; of another, the scale is $\frac{3}{8}''=1'$; and so on. For the plot of a survey made for engineering purposes, a unit space (30) on the paper represents some multiple of ten feet on the ground. That is, the scale of a map is usually $1''=10'$, $100'$, or $1000'$, etc; $1''=20'$, $200'$, or $2000'$, etc.; or $1''=30'$, $300'$, or $3000'$, etc.; and so on. Every unit space on the engineer's scale is subdivided into 10 equal parts. Every tenth line is numbered, beginning with the first, which bears the number 0 (zero). Fig. 45 should be studied in connection with the engineer's triangular scale (30).

On a structural or machine drawing, each unit space represents $1'$ on the object. The length of each unit (30) on an architect's scale is given by the number printed in large figures under the initial unit, which alone is subdivided into twelve equal parts. The unit spaces are numbered as shown in Fig. 46, which should be carefully studied.

The scale of a map should always be stated (as in Fig. 36), or shown by a drawn scale, together with the representative fraction (Fig. 49), or both. On a small-scale map it is well to draw also a scale of miles in the title space. For a working drawing it is customary to simply state the scale, thus: Scale: $\frac{1}{8}''=1'$; or to omit the scale altogether.

96. To Cut the Paper.—In the drafting-room of a machine shop or bridge shop nearly all the drawings are made on a few sizes of paper which are fixed (usually on the basis of convenient filing) by the chief engineer or chief draughtsman. Students' drawings are, for the most part, made on a few designated sizes of paper. For certain classes of work it is impracticable to keep on hand enough sizes of sheets to accommodate the required drawings; and for each drawing the paper is cut from a roll. The drawing may be made on an ample portion of the roll paper, which has been unrolled (but not cut off) and tacked on the board. After this the border and cutting lines are located and ruled, and the sheet cut. This is inconvenient and wasteful of paper. Usually a piece is cut from the roll of paper before the drawing is begun. In this case it is necessary to know beforehand what will be the length and breadth of the finished drawing. For structures and machines there is usually no trouble in finding the extreme height and length (or width) of the object or part to be shown.

For a map, the required size of the paper may be determined by one of the following methods: *First Method.*—Compute the co-ordinates of the limiting points of the area to be mapped, using preferably north and south and east and west axes so chosen that all the points are thrown into one quadrant. (The N. and S. line should usually be parallel to the vertical edges of the map, north up.) The maximum abscissa and the maximum ordinate will be (to scale) the minimum lengths of the border lines. The border lines should be somewhat longer than absolutely necessary, that they may not seem to crowd the interior lines of the drawing. The lengths of the cutting lines (49) are now determined by adding to the border lengths the widths of the margins (101) desired. Usually somewhat more paper is cut than is required, the extra part being taken at one side of the sheet for use in testing the pen after each filling or setting. *Second Method.*—Roughly plot the limiting points of the survey on one or more sheets of detail- or cross-

section-paper. If two or more sheets are required, they are overlapped to serve as a continuous sheet. Locate the border lines, leaving sufficient room for the map and title. Locate the cutting lines, giving the margins the desired widths. The drawing-paper for the finished map is cut to the dimensions of this rough plot. Use the first draft as a model in laying out the first lines on the accurate map. *Third Method.*—Plot the principal points of the survey accurately on one or more sheets of detail- or drawing-paper. Find the dimensions for the finished map and cut the paper for it, as in the second method. Place the first draft on this paper so that the map will lie symmetrically on the space to be bounded by the border lines. Prick the located points through with a fine needle-point, being careful to hold the needle perpendicular to the paper and to make only minute holes in the under sheet.

97. To Stretch the Paper.—For drawings to which water-color is to be applied, it is necessary to stretch the paper. The advantages of having a perfectly flat surface to work on will often make it pay to stretch the paper for an accurate pencil or ink drawing. A sheet of drawing-paper is stretched in the following manner, using a clean drawing-board, clean hands, clean sponge and glass, clear water, fresh blotters, and liquid glue or strong mucilage:

(1) Cut the paper to allow a margin of $\frac{1}{2}$ " (or more, according to the size of the sheet) outside the cutting line (49).

(2) Turn up this outer margin on the four sides, making a shallow tray of the paper.

(3) Turn this tray bottom up, on the horizontal drawing-board.

(4) Wet the bottom (not the sides) of the tray, by gently tapping with the saturated sponge.

As soon as the paper begins to sag in the center, squeeze the water from the sponge as it is passed above the higher parts of the paper. (The water should not touch the turned up margins nor get on the drawing-board.)

(5) As soon as the paper (except the turned-up margins) is perfectly limp, take up the water with the sponge, without rubbing the latter on the paper.

(6) Coat the dry margins with the mucilage.

(7) Taking the paper by the two far corners, lift it from the board and lay it, right side up, in its proper position on the board.

(8) With the finger tips, press one long margin on the board, rubbing outward from the margin center. Treat the other margins (beginning with that opposite the first) in the same way.

(9) Go around the sheet repeatedly, repressing the margins by drawing the finger tips away from the center of the sheet.

It is advantageous to have a helper, so that opposite margins can be pressed down and drawn out at the same time. Otherwise it is a good plan to drive thumb-tacks into the margin first pressed down. The mucilage must set firmly before the sheet dries. Keep the board in a horizontal position, away from the sun and artificial heat. Usually the paper should not be drawn on till the following day. Notice that in the above operations no water is applied directly to the working surface of the paper.

§ 14. *Linear Drawing Applied to Drafting.*

98. To Pencil a Drawing.—The precision with which points and lines are marked should depend altogether on the required accuracy of the finished drawing. All lines should be drawn fine (with slight pressure) and full till their limits are determined, when they may be redrawn heavier, and full or broken as desired. It will not usually be necessary to show lines

broken till they are inked or traced. Lines which are to be traced should be redrawn with a sharp chisel-point (17) with some pressure, that they may show well through the cloth. For a drawing on which the dimensions are to be inked or traced, write in each dimension lightly but clearly as it is laid off. Also write those descriptive words which are to appear on the final work at the time of drawing the parts to which they belong. After all the lines are drawn, print the dimensions, descriptions, and title (§ 15).

The order of penciling lines and laying off distances on a drawing varies with the character of the object to be represented. There is usually on an object at least one horizontal to which we naturally refer other lines of the object: *e. g.*, the bottom or base line of a machine, a horizontal axis of symmetry in some part of a machine, the floor line of a building, high-water lines on river and harbor structures, the grade line on a bridge for highway or railroad, etc. Also, there is commonly on an object one or more vertical lines with respect to which we are accustomed to locate other lines, *e. g.*, a vertical axis of symmetry of a machine part, trestle bent, bridge pier, or truss cross-section, vertical lines of walls, etc. If the object has such a reference line, we place this line on the paper in such a position that the completed drawing will occupy its proper position within the border line. If there are two or more horizontal or vertical reference lines, one is drawn first and the others are located on the paper with respect to this. In locating a point when there are two or more parallel reference lines, that one will be used which gives the least work.

By way of illustrating the foregoing, the steps taken in making the drawing of an apron-stud, Fig. 42, are here given: (1) Draw an indefinite horizontal line to represent the long axis of the stud. (2) Knowing all the dimensions shown in the figure, begin at a chosen point toward the

left end of the drawn line and lay off consecutively (to scale) to the right the distances $1\frac{1}{4}"$, $1"$, $\frac{1}{4}"$, $1\frac{1}{4}"$, $1\frac{1}{4}"$, and $1"$, making a fine dot on the axis at the right extremity of each distance. (3) Draw an indefinite fine line perpendicular to the axis at each marked point. (These lines are drawn one after another, beginning at the left-hand point, with the triangle sliding along the T blade while the head is in full contact with the left edge of the board.) (4) On the first vertical line lay off (to scale), upward from the axis, $\frac{1}{2}"$ (one-half the diameter of the screw at the left end of the stud); lay off on each vertical, in turn, the corresponding half diameter; with the divider, lay off each half diameter below the axis. (5) Draw horizontal lines through the outer ends of the half diameters to form with the vertical lines the outlines of the stud. (6) The details of the screw threads are constructed next. Lines which have been located by measurements made from and along the first line drawn, serve in turn as reference lines for groups of details. (7) If the drawing is to be traced, the outlines are redrawn with a sharp chisel-point. (8) The dimension lines (102) are drawn where they will least interfere with the clearness of the outlines and where there is the least danger of misunderstanding to what they refer. (9) The guide lines are drawn for printing the dimension figures, descriptive words, and one-line title, after which the printing is done with pencil (§ 15).

Some of the details of the above construction may be varied, *e. g.*, the distances may be laid off from the right instead of the left, or from any point chosen, to the right and left; the two ends of a diameter may be located at one placing of the scale (this is the best method when the scale is divided full length), or each half diameter may be taken from the scale with the divider and laid off upward, and then downward by swinging the upper divider point about the lower, which rests on the axis.

For a map, we first draw a pair of rectangular axes, a north-and-south line, a base line, or

one of the longest straight lines of the survey, according to the method of making the survey. The student should consult some work on topographical drawing* for the details of map work.

99. To Ink a Drawing.—It is bad practice to begin to ink a drawing before the pencil work has been completed. A drawing should be so inked that the outlines of the object represented become known at the first glance, while the projection and dimension lines (102) and other details become clear only on closer inspection. To this end the lines of a drawing are made heavy and light, full and broken. Three representative sets of conventional lines are given in Fig. 43.

Lines should neither run over nor fall short of their limiting points. Dashes of broken lines should not cross full lines. The segments of broken lines should be made as uniform in length and spacing as is possible by eye. Straight lines and curves should be smoothly joined. Irregular curves, too sharp for the French curve, are put in free-hand with the lettering-pen.

In drawing hidden *outlines*, which are near together and parallel, make the segments of the lines break joints, as shown in Fig. 43.

A *heavy line* may be drawn with one stroke of the ruling-pen set wide, as already indicated (56), but for outline shading the following method is often used: First rule, say, a horizontal fine line. Rule a second line (with the pen set as before or a little wider) below and parallel to the first. The second line is ruled to just touch the first or to leave a white space between, depending on the required width of the finished line. The white space if narrow is filled by a third stroke of the pen, which is slanted to reach the white space without moving the guide

*One of the standard works is "Topographical Drawing and Sketching," by Lieut. H. A. Reed (John Wiley & Sons, N. Y., \$5).

from its second position. If the white space is wide it can be filled by repeated rulings with the ruling-pen, or with ink applied with a lettering-pen or water-color brush.

To shade a circle: First draw a fine line circumference (Fig. 47). With the same radius and pen setting, draw the lower right half of a circumference from a center located to the right of and below the first center on a 45° line through the latter. The distance between centers is regulated by the desired weight of shade at the middle of the right lower quadrant. If there is a white space left between the two arcs it is filled by a third arc drawn from a third center midway between the first two, or with a lettering-pen or a brush.

The order of inking the lines of a machine or structural drawing with the least chance of mistakes is as follows: *A. Outlines.*—(1) Curves (a circle is most conveniently shaded as soon as drawn, while the compass is open to the radius); (2) horizontal lines (fine), beginning at the top; (3) vertical lines (fine), beginning at the left side of the drawing; (4) sets of parallel oblique lines (fine); (5) odd lines (fine). *B. Projection and dimension lines.*—These are drawn in the order (2), (3), etc., given above. *C. Shading.*—The right-hand and lower outlines of projecting parts are shaded (*i. e.*, made heavier) as indicated above. The shaded line should usually be little, if any, more than twice as wide as the fine line. *D. Lettering.*—Ink the figures and letters.

Time may be saved, at the risk of mistakes, by setting the pen wide to rule each shaded line at one stroke. In this case the fine horizontal and vertical lines are drawn first, and the heavy lines afterward drawn in the same order. The extra width of each heavy line thus drawn should lie without the true outline of the part, *i. e.*, the shading should not encroach on the object or part.

100. To Make a Tracing.—Cut the cloth extra large, so as to have a strip outside the cutting line (49) for use in trying the pen after each interval in the ruling of lines. Tack

the cloth to the board, two diagonally opposite corners first, so that it lies smooth over the drawing to be traced. If the glossy side is turned up (16) the gloss is removed with pumice powder (29). While tracing, occasional grease patches may be discovered by the ink's not taking hold of the cloth or by the sudden unloading of the pen. This oil is easily removed by the application of a little pumice powder. The character of lines and the order of making them are given in 99. Ink will enter a break in the surface of the tracing-cloth and follow along the threads. It is therefore important that erasures be made with pumice powder instead of steel, and that circles be drawn without making holes at their centers. When ink enters the interior of the cloth by way of natural defects in the surface, the only remedy is to take a new piece. To make good lines, free from tails and blots at the ends, it is necessary to keep the cloth flat on the board in the vicinity of the working pen nibs. To make uniform lines, the ruling-pen must be moved at uniform speed.

101. Margins; Border Line.—The *widths of the margins* (50) for students' drawings are usually prescribed by the instructor. For drawings which are to be preserved in quantities, *e. g.*, blue-prints in machine-shops, the margin is often as narrow as $\frac{1}{4}$ ". For display drawings made on drawing-paper the width of margin ranges from 1" to 2" for a drawing 2' x 3', to 4" to 6" for a drawing 5' x 7'. It is best to make provision for an ample margin when cutting the paper, as it is convenient to have a narrow strip at one side of the drawing, on the outside of the cutting line, on which to try the pen after each filling.

The *border line* for students' and working drawings may be a single line no heavier than can be drawn conveniently with one ruling. For large-scale maps larger than 2' x 3' and for all carefully drawn small-scale maps the border line may consist of an outer heavy line and an inner fine line, the width of the former being equal to the space between the two. The distance

from the fine line to the outer edge of the heavy line is taken as one one-hundredth of the length of the shorter border line of the map, as shown in Fig. 49. In all cases make the corners plain, as shown.

102. Conventions.—A *meridian arrow* is drawn not to ornament the map but to show the direction of the meridian (true or magnetic) with respect to the plotted lines. A single straight fine line answers this purpose. The head and tail of an arrow are put on the line to make it a little more conspicuous for easy finding. If the magnetic meridian, only, is known, a single arrow gives its direction; in which case “Mag. N.” is printed above the head, or “Magnetic Meridian” along the shaft of the arrow. When the true meridian is known the magnetic meridian is usually also known, and their directions are indicated by a double arrow, as shown in Fig. 50. The half head and half tail are used on the line of the magnetic meridian. The angle between the two meridians, the “declination of the needle,” is printed as shown. The length of the arrow should be equal to that of the hypotenuse of that triangle which is of the most convenient size for drawing the longer lines of the map. The arrow is placed on the largest clear space not set off for the title. In case of lack of clear space, the arrow is placed on the drawing proper, in such a position that it will neither cover nor confuse important details.

Drawn Scale.—Fig. 48 shows a scale of simple design, well suited to ordinary maps and to working drawings.

Metal Sections.—In Fig. 44 are shown conventional section linings for cast iron, steel, wrought iron, and brass.*

* Section linings for other metals are given in books on Machine Drawing. In Rheinhardt's “Technic of Mechanical Drafting” will be found about seventy conventions, covering the various materials dealt with in Civil and Mechanical Engineering.

A *dimension line* (Figs. 38, 42, 43) terminates in arrow-heads whose points touch the lines which limit it. A break is left in the middle of the dimension line for the insertion of the dimension figures. The arrow-heads should be uniform in size and shape. In case there is not enough room for the arrow-heads placed in the usual way, they are reversed and placed outside the limiting lines. For full dimension lines, see "Projection lines" below.

Projection lines (called also *reference lines*) are shown dotted in Fig. 42. In Fig. 43, under "Style C," the projection and dimension lines are shown full. These are more quickly drawn than broken lines, and offer fewer chances for mistakes in reading a drawing where projection or dimension lines are crowded. There is no danger of confusing the full dimension and projection lines with the outlines of the drawing when the former are made very fine and the latter are made heavy (for shaded outlines) and medium (for unshaded outlines), as shown.

§ 15. *Lettering Applied to Drafting.*

103. Choice of Styles.—The Vertical and Inclined styles (Figs. 30–34) are each suitable for all lettering on a working drawing (Fig. 38); but it is a good plan to use both styles on the same drawing: the Inclined for dimension figures and descriptive lettering, and the Vertical for titles, sub-titles, and reference characters (Fig. 42). The letters may be compressed to save space, or extended to give greater prominence (Figs. 35, 42). Roman letters should be used on all drawings for which the above styles are not appropriate.

104. Size and Position of Letters and Figures.—The height of the descriptive letters and dimension figures throughout a drawing should be uniform and not less than 3 mm. ($\frac{1}{8}$ " for capitals.

A *dimension number* is printed in the direction of its dimension line, and in the space left in this line for this purpose. When a dimension number is too large for the space which it would naturally occupy, it is placed in the nearest sufficiently large blank space and connected with its dimension line by a dotted line which ends in an arrow-head or heavy period (Figs. 38, 42, 44). Numbers on vertical lines are printed so as to be read from the right-hand edge of the sheet.

Descriptive words are printed along the part to which they belong, if possible; otherwise in the nearest blank space of sufficient size, and connected to the part by a dotted line which terminates in an arrow-head at the part. When descriptive words are printed along vertical lines, they are so placed as to be read from the right-hand edge of the sheet.

Unless there is reason for giving lines of letters and figures some slope, they are made horizontal.

105. To Make the Letters and Figures.—Whether the pencil drawing is to be inked or traced, the beginner should carefully draw the letters and figures in pencil on the original drawing, using guide lines (Nos. 1, 3, 6, 8 of Fig. 34). For drawing the guide lines, make four marks, properly spaced, on the edge of a triangle. Place the marked edge in such a position on the drawing that lines drawn perpendicular to this edge through the marks will be correctly located to serve as guide lines for a line of letters or figures. Another and quicker method is to cut two parallel rectangular slots in a visiting card, piece of heavy drawing-paper or thin sheet-metal, in such a way that the upper and lower edges of the two slots will serve as straight-edges along which to draw correctly spaced guide lines.

106. The Title of a Drawing.—A title for a drawing should be designed by one who appreciates what will be required of the drawing by those who are to use it. The common rule is to embody in the title the name of the object and its location, the persons for and by whom

the object is constructed, the scale of the drawing, and the date. A drawing may, however, require a title as simple as that given in Fig. 37, or as complex as the following: "Survey of the Northern and Northwestern Lakes || Made in obedience to acts of Congress || and orders from the || Headquarters of the Corps of Engineers, War Department. || Chart of the Northern and Northwestern Lakes || Compiled from the data || of the || U. S. Lake Survey. || Scale 1:18,000,000. || Published in 1879. || Compiled and drawn by Edward Moliter. || Scale of Statute Miles."

The height of the largest letters in a title is usually one-fiftieth of the length of the shorter border of the drawing. The vertical spacing of the lines of letters of a title is made less than indicated in Fig. 36 whenever the space available for the title is restricted.

The title is placed on both ends of drawings which are long and narrow, *e. g.*, profiles and route maps. On drawings which are to be filed in drawers, the title is usually placed in the right lower corner. On miscellaneous drawings the title is placed on the largest blank space within the border.

107. Lettering on Tracing-cloth.—In tracing, it will, at first, be necessary to trace the guide lines with pencil before inking the letters and figures. Special effort is required to make all parts of each character absolutely black and distinct. Beginners are apt to produce, on tracing-cloth, lettering-pen strokes which are faint at one or both ends. This may be because the strokes are made with irregular pen pressure, or because not enough time is given the ink to take hold of the cloth. The tracing-cloth should be kept pressed firmly against the board where the pen is working, to prevent the tails and blots which are apt to be formed on each stroke by the cloth's rising and following the pen as the latter is lifted at the end of a stroke.

After a certain amount of practice in lettering, the formal penciling of letters may be omitted on the original and inked properly on the tracing by sliding a slip of paper, marked with lettering guide lines, underneath the cloth to the proper position.

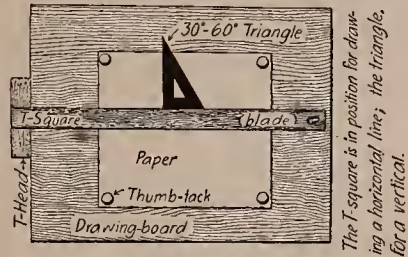


FIG. 1 (Not drawn to scale).

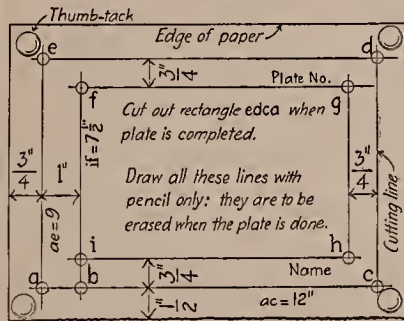


FIG. 2 (Not drawn to scale)

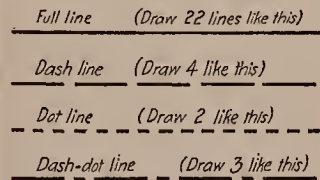


FIG. 3 Medium Lines (for Plate 1)

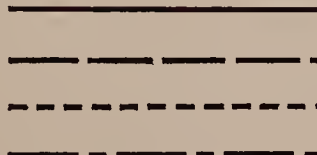


FIG. 4 Heavy Lines (for Plate 2)

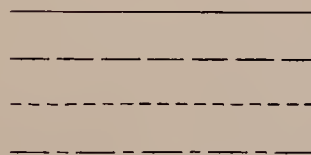


FIG. 5 Fine Lines (for Plate 3)



FIG. 13



Side View End View
Chisel-Point
(Full Size)

FIG. 14



Cone-Point
(Full Size)

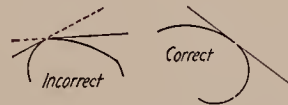


FIG. 16

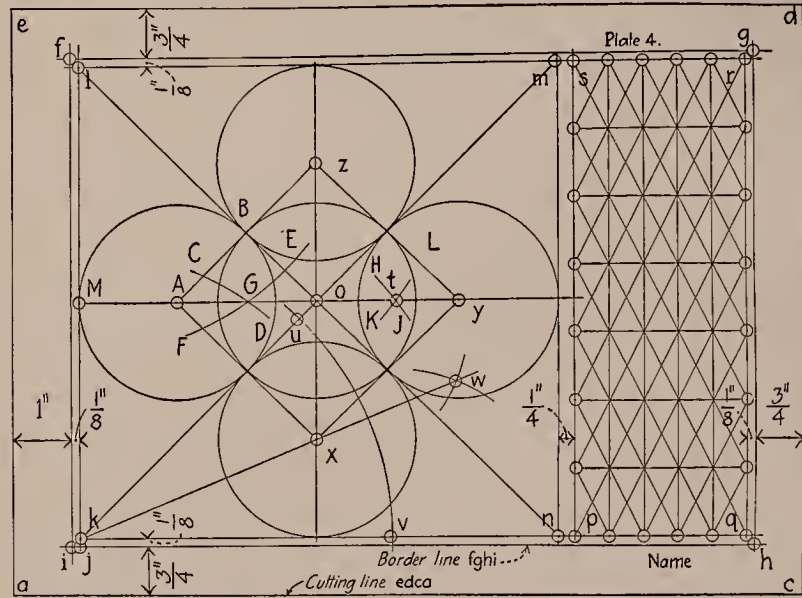


FIG. 12

FIG. 15 (Not drawn to scale)

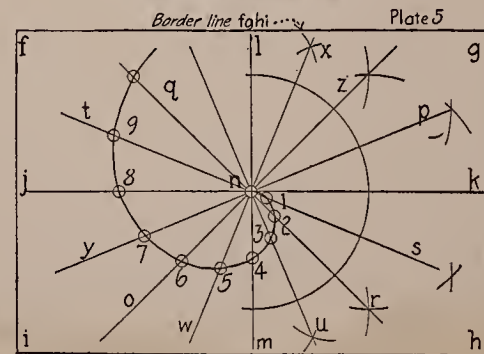




FIG. 17

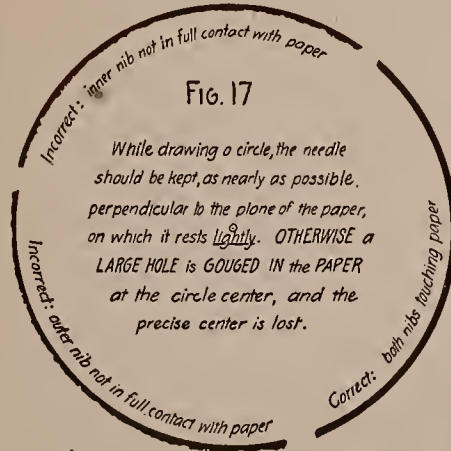


FIG. 18

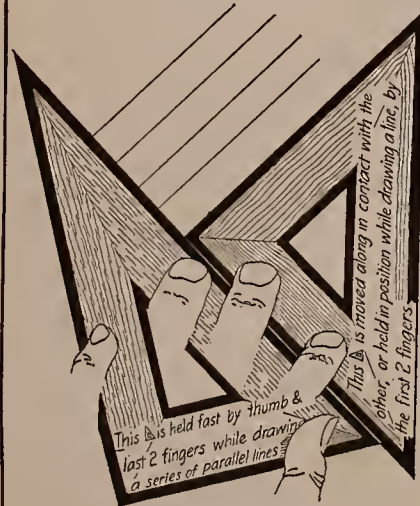
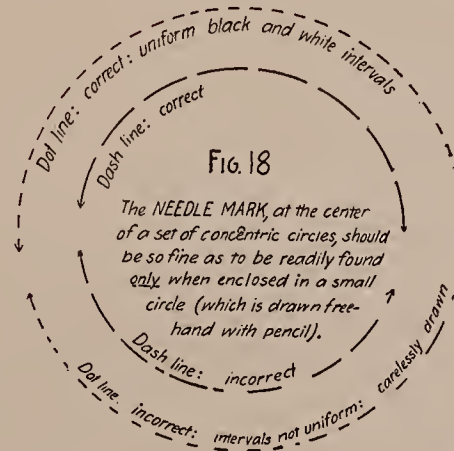


FIG. 21

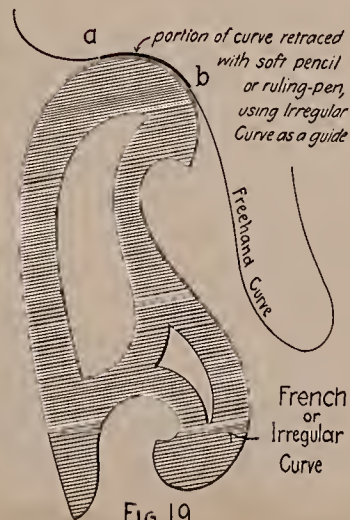


FIG. 19

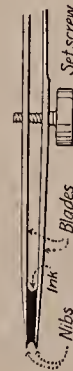


FIG. 20

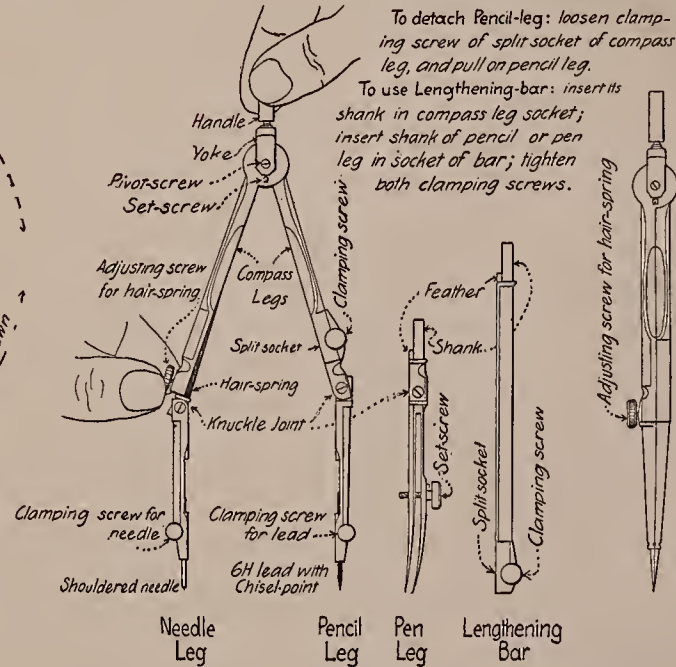
Compass
FIG. 22Divider
FIG. 23Bow Divider
FIG. 24

FIG. 25

Nib of Ruling-Pen

Showing Corrosion which results from careless cleaning of the Blades.

Always wipe the Nibs, inside and out, DRY and BRIGHT after using the pen.





WINNEMUCCA

NEVADA

Surveyed by William H. Olds

Scale: 1 inch = 1000 ft.

1901

C. M. & S. P. Ry.

BRIDGE & BUILDING DEPT.

Standard Frame Bent Trestle

Milwaukee, March, 1899

Fig. 39

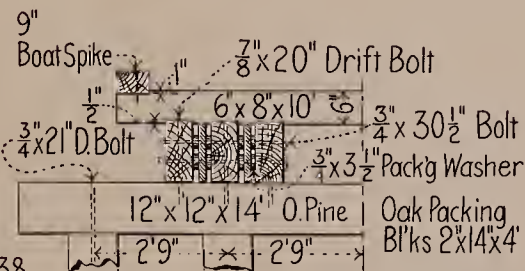
Fig. 40

Fig. 41

Fig. 36

Fig. 37

Fig. 38



Half Transverse Section

18" Shaft-Hanger

Scale Half Size August Green

Compressed

Compressed lettering is used
to save space on a drawingExtended Lettering
is used for Emphasis

Extended

Fig. 35

o o o l o c d e f g h i j k l m n

2 2 2 3 3 4 5 5 6 6 7 8 8 9 9 A B C D E F G H I J K L M N

Fig. 34

p o r s t u v w x y z

9' 8" 27" 9' 8" 27" 1 2 3 4 5 6 7 8 9 10 P Q R S T U V W X Y Z

Fig. 33

a b c d e f g h i j k l m n o p q r s t u v w x y z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Fig. 32

a b c d e f g h i j k l m n o p q r s t u v w x y z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z & 2 3 4 5 6 7 8 9

Fig. 31

a b c d e f g h i j k l m n o p q r s t u v w x y z A B C D E F G H I J K L M N O P Q R S T U V W X Y Z &

Fig. 30





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